A QUANTITATIVE ANALYSIS OF DEFENSE EXPENDITURE PATTERNS IN WARSAW TREATY ORGANIZATION COUNTRIES 1960-1974

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THESIS

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by

John G. Kuchinski, Jr.

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Non-parametric statistical methods as well as correlation and regression analysis are used to uncover the various factors most influential in WTO defense budgeting, both region-wide and for

specific member countries.

Forecasting models are developed for use in predicting military expenditures for individual countries as well as the "typical" WTO country. A general discussion of model use with different data sources is also presented.

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I. INTRODUCTION

A. BACKGROUND

The Warsaw Treaty Organization (WTO) was formed on 14 May 1955 when the leaders of the Soviet Union, Albania, Bulgaria, Czechoslovakia, German Democratic Republic (GDR), Hungary, Poland and Rumania met in Warsaw for the signing of the Warsaw Treaty of Friendship, Co-operation and Mutual Assistance [1]. The alliance was reduced to seven countries with the defection of Albania in September 1968 [2]. However, the real cornerstone of the Soviet military-political power in Eastern Europe is the network of bilateral treaties with the so-called WTO nations. In describing the importance of these treaties Erickson [2] states:

> "What these treaties insure is direct Soviet control over security affairs in Eastern Europe: equally, even if both 'military blocs' (NATO and the Warsaw Pact) were 'dissolved', which is one of the political formulations frequently advanced, this would have little effect on the Soviet Union's security arrangement in Eastern Europe at large."

Hence the WTO was not established as a military alliance but more as a political response to NATO. In essence, the WTO provided a formal organization through which the Soviet leaders could direct, control and co-ordinate the political, military and economic assets of Eastern Europe while legalizing the permanent stationing of Soviet troops in the region. The Soviets also hoped to reduce the visible signs of Kremlin

domination over Eastern Europe by giving the WTO the appearance of a multi-lateral forum of independent nations while also guaranteeing the area as a Soviet buffer zone.

Historically, the WTO has been treated by Western analysts as a dormant organization used by the Kremlin to organize Eastern European support for Soviet policies. This is evident in the unevenness of the literature on NATO and the WTO. There has been a constant flow of scholarly writings on NATO while only a pittance of informed writings on the WTO. This occurred primarily because Western analysts have been preoccupied with the subject of strategic and nuclear forces, weapons and postures which tended to exclude the conventional forces in Eastern Europe. The situation has changed in recent years, for as the vitality and influence of NATO has declined, a steady increase in WTO forces, weapons and capability has raised the fears of Western leaders.

B. PROBLEMS

The purpose of this thesis is to provide a quantitative study of WTO military expenditures so as to expose the underlying factors which most influence the defense policies for each of the six Eastern European members. The difficulty of the task is complicated by the lack of reliable data. Unlike Western countries where statistics on the National Budget, Gross National Product, Industrial Output, Trade, Balance of Payments, etc. are accurately reported, WTO countries treat such accounts as state secrets. This is not to say that

official statistics are not published, but too frequently they are stagnant values repeated from one year to the next. To gain a true perspective of the problems, successes or failures in the various categories, Western analysts have turned to examining available data and intelligence for use in estimating the actual values. The estimation of military expenditures or Gross National Product is not a highly refined process. Many times the methodology is crude and estimates from different analysts vary substantially. Another formidable problem is the use of suitable exchange rates for the conversion of domestic currency to U.S. dollars so that real changes in the process are not shielded or exacerbated by the effects of inflation on Western currencies. The fact that Eastern European currencies are not readily exchangeable for Western currencies has provoked further analysis in the areas of purchasing power parities. It is true that official exchange rates exist, but these frequently overvalue the local currency. There is also the problem of comparing estimates of different phenomenon such as military expenditures and Gross National Product. Frequently different exchange rates and price deflators are applied which make the two dollar values incompatible when used together.

Thus, two basic problems are confronted: 1) Extracting from the data those factors which play the major role in defense policy decisions in individual countries, and 2) using the different data sources and other available information to set some measure of confidence in the estimating accuracy of the various sources.

C. METHODOLOGY

The intent of this thesis is to uncover the underlying factors that influence WTO defense spending. To accomplish this the various data sources are examined and the broadest, most consistent sources chosen for use in the analysis. A cross-sectional analysis is then performed across the seven WTO nations where correlations, between military spending and each of four variables, hypothesized to have an explanatory effect, are computed. This is done for two years; 1966 and 1974. Then regression is used to construct predictive models for the "typical" WTO country. The cross-sectional analysis is concluded with a brief investigation of various ratio variables which enable a rank ordering of WTO countries in three categories: 1) Economic burden of Defense Spending, MX/GNP; 2) Economic wealth or ability to pay for defense, GNP/POP, and 3) Militarization, NMILT/POP.

The longitudinal analysis follows by first investigating the relationship between conformity to Soviet defense policy and 1) trade dependence of individual WTO members on the USSR, 2) economic development of European members, and 3) susceptibility of European members to Soviet military intervention. This is accomplished by constructing various indices of conformity from the time series data. Then non-parametric statistical methods are used to compute correlations and test the results for significance. The longitudinal analysis concluded with a thorough examination of each of the six European members defense

spending history and a set of 31-33 economic and military variables hypothesized to carry explanatory effects. Correlation analysis is used to sort the 31-33 variables into rank order statistics where comparisons of correlates between sources can be made. Predictive models are constructed for each source using regression analysis thus enabling the analyst to forecast military expenditures for specific countries.

The author utilized various computer programs in the analysis. APL programs for Least Squares Regression, Smoothing and plotting were developed by McNeil [3]. APL programs for computation of Pearson correlations, the Hildreth-Lu Grid Search and Generalized Differencing procedures as well as a Fortran program for multiple stepwise regression were developed by Professor F.R. Richards of the Naval Postgraduate School. The Statistical Package for the Social Sciences (SPSS) was used in computing all Spearman and Kendall Correlations. The list of acronyms and abbreviations used in this thesis can be found in Appendix A. All data, variables and sources are listed in Appendix B.

II. DATA BASE

A. MILITARY EXPENDITURE ESTIMATES

Determining military expenditures for the WTO countries is a special problem because a) their large arsenal of sophisticated weaponry and manpower resources clearly makes them major military powers, and b) the published defense budget is relatively small and unreal for such a force. The true cost of fielding such a force is a closely guarded state secret known only to the most senior military and political officials. NATO policy-makers need valid measures of the WTO defense budget in order to assess Pact objectives, priorities and capabilities. For this reason, various methodologies have appeared for use in estimating the actual cost of the WTO defense program. These estimation methods generally fall into three categories: 1) The CIA Direct Costing Approach; 2) The Stanford Research Institute (SRI) Approach and 3) The W.T. Lee Approach. Reference 4 gives a good account of all three methods as applied to estimates of USSR military expenditures.

1. CIA Direct Costing Methodology

A description of the CIA Direct Costing Methodology as applied to the USSR was given in 1974 by the then CIA Director William E. Colby, to the Joint Economic Committee, Subcommittee on Priorities and Economy in Government, chaired by Senator Proxmire.

"This procedure involves identifying Soviet military programs, estimating the magnitude or the quantities involved in each program, and then applying estimated individual prices to each quantity. All Soviet military activities other than the military research and development figure are estimated by this procedure and are thus independent of the published spending figure." [4]

In essence, the Direct Cost Methodology attempts to make a detailed list of all identifiable assets, components and activities that make up the defense program. In the CIA estimates for the USSR this listing is broken down into five components: 1) Procurement (PC); 2) Personnel Pay and Maintenance (PPM); 3) Operations and Maintenance (O&M); 4) Military Construction (MC), and 5) Research, Development, Testing and Evaluation (RDT&E) and Space. Each component is costed separately and then summed to reach the final Budget Estimate (BE). The following is the basic Direct Cost Model.

$$BE = \sum_{i=1}^{5} \sum_{j=1}^{n_i} Q_{ij} P_{ij}$$

Q_{ij}=Quantity of unit j of component i

P_{ij}=Price or Cost of unit j of component i

n_i=Total number of unit items in component i

Each of the components in the Direct Cost Model rely on either the known P in local currency, or the estimated P costed at U.S. prices, and then converted to local currency. The CIA uses known values of P for PPM and MC, and estimates of P for PC and O&M. The following discussion gives a brief sketch of the costing methods for each of the five component areas.

a. Procurement

Estimate the cost using known or estimated performance parameters by applying one of the following methods:

(1) Assign a Comparable Cost

Use the existing cost of a comparable U.S. system. This method provides a rough approximation to the cost and is not normally used unless a quick estimate is needed.

(2) CER's

Use Cost Estimating Relationships (CER's) for various components and sub-systems of the item. This gives components costs which can be summed to yield system cost (e.g., Ruble Cost of Aircraft = Engine cost + Airframe cost + Avionics cost).

(3) U.S. Procurement Cost

Develop the cost of producing the system in the U.S. to USSR specifications and in the quantities produced by the USSR.

b. PPM and MC

Personnel Pay and Maintenance and Military Construction are the strongest part of the Direct Costing Methodology. Pay scales for military personnel are known and applied to estimated force manning in local currency. In Military Construction, there is detailed information available on the physical construction of military facilities. Hence these items can be costed out using known prices in local currency for materials and labor.

c. O & M

Local prices are used in costing Operations and Maintenance if known, otherwise estimates are made using dollar prices or percentage factors (i.e., cost/flight hour, cost/ square foot, etc.).

d. RDT & E and Space

No direct costing is applied in RDT & E and Space. The CIA accepts the published budget figure with certain minor modification.

e. Summary Direct Costing

(1) All known items in the defense program are listed in five component areas.

(2) Unit costs are assigned using local currency (if P known) or dollars (if P unknown) and then converted to local currency.

(3) Costs are multiplied by quantities and summed to yield the final budget estimate.

The final budget estimate is then a combination of local currency values (when P is known) and dollar values (when P is unknown and estimated by $P_{U.S.}$). There is no doubt that errors of varying magnitude can result depending on the degree of uncertainty surrounding the systems, and of course the care to which the analyst employs the methods of estimation.

2. Stanford Research Institute Methodology

The SRI Methodology accepts the published budget figure for Defense and supplements this figure with estimates thought

to be military spending hidden in other budget categories. For example, in the case of the USSR, the SRI

> "...has accepted the published 'Defense' appropriation and 'Science' expenditures as total USSR outlays for National Security Expenditures (NSE) and for Civilian R & D." [5]

Thus, the SRI estimate is simply the total of the published Defense budget plus a percentage (50-100%) of the Science budget.

It is not surprising that many Western analysts are dubious of the SRI estimates. W.T. Lee [4] claims much evidence is available suggesting that the published figures cover only PPM, O & M and MC.

a. Summary SRI Methodology

(1) Budget estimate equals published Defense expenditures plus a percentage of other budget categories thought to contain military items.

3. W.T. Lee Methodology

The methodology developed by Lee emphasizes officially published data. For example, Lee's estimates for the USSR are based entirely on statistics published by the Soviet Union.

Lee estimates total defense spending as the sum of three components: 1) National Security Durables (tanks, guns, ships, aircraft, missiles, etc.), 2) Personnel Pay and Maintenance, Operations and Maintenance, and Military Construction, and 3) Military RDT & E and Space.

Lee estimates the NS Durables procurred (in his USSR estimate) by examining

> "...published data on machinery and equipment output and allocation thereof to investment and consumption, and the ratios of final demand to gross output from the 1959 and 1966 Input-Output (IO) tables as constructed by US scholars." [4]

Uniformed personnel costs come directly from published sources while he uses budget figures (Defense less Uniformed Pay) to represent the O & M and MC costs. The RDT & E and Space figures are estimated in two ways:

> "...1) by calculating an approximate value of the output of proto-types and space hard-ware, and then estimating the other components of R & D, and 2) by summing labor, capital and material inputs to the RDT & E performing institutions." [4]

a. Summary Lee Methodology

(1) Uses published data for three components (NS Durables, O & M and MC, and Military RDT & E and Space).

(2) Uses economic techniques such as input-output tables to estimate production rates, capacities, etc.

(3) Sums all components at local prices to arrive at budget estimate.

4. <u>Comparisons</u>

Table I contains ruble estimates of USSR defense spending for 1970 and 1975 utilizing the methodologies of the CIA, SRI and W.T. Lee. The CIA figures reflect the 1976 revision in the estimated ruble budget.

TABLE I

USSR DEFENSE SPENDING (bil Rubles) [4]

	1970	1975
CIA	45 - 50	55 - 60
SRI	21 - 24	22 - 26
LEE	42.5 - 49.0	66.5 - 76.0

There appears some measure of consistency between the CIA and Lee estimate. The SRI estimates are roughly 50% of the other two estimates. This result can provide some support for the Direct Costing Method and perhaps dispel the contention that published data has no useful purpose in the estimation of budget totals.

B. SOURCES AND ESTIMATION METHODS

In reviewing available literature on WTO defense spending, the major focus appears to be on the Soviet Union. The CIA, SRI and Lee methodologies were all developed to estimate USSR expenditures but the same techniques are also applied to Eastern Europe.

Data on WTO military spending is generally available from three different sources: 1) The U.S. Arms Control and Disarmament Agency (ACDA); 2) The Institute for Strategic Studies (ISS) and 3) The Stockholm International Peace Research Institute (SIPRI). The Central Intelligence Agency is known to

be active in Eastern Europe defense budget estimation, but a request for data by the author was rejected.

The ACDA data set was produced under ACDA contract to the RESEARCH PROJECT ON NATIONAL INCOME IN EAST CENTRAL EUROPE through L.W. International Financial Research, Inc., New York, New York by Thad P. Alton. The latest ACDA publication, "World Military Expenditures and Arms Transfers 1965-1974" of 31 December 1975, does not contain the Alton estimates prior to 1965. To go back to 1960, the author obtained Alton's original paper, "Military Expenditures in Eastern Europe: Some Alternative Estimates" published in the Joint Economic Committee of Congress Compendium, REORIENTATION AND COMMERCIAL RELATIONS OF THE ECONOMIES OF EASTERN EUROPE, July 1974. These estimates cover the period 1960-1974 and were produced using a modified Direct Costing technique. This modification revolves around the Personnel Pay and Maintenance (PPM) category where the salaries of WTO Armed Forces personnel are costed in U.S. dollars vice local currency. Alton is not clear as to why dollar-costing is preferable to the domestic-costing used in PPM by the CIA (for USSR estimates). He does make one adjustment however, determining that while U.S. and WTO officers should be costed equally, WTO enlisted personnel receive only 75% of their U.S. counterparts pay (because of lower technological qualifications). The remaining budget categories are costed in domestic currency, totaled, and then converted to dollars. Alton does not defend his methodology, other than

suggesting it provides a suitable alternative to the SIPRI and ISS methods which rely on published official data.

The SIPRI and ISS data sets are estimated using the SRI method. The official state budget appropriations are adjusted upwards with outlays from other budget categories thought to contain Ministry of Defense items. The SIPRI estimates are published in the "World Armaments and Disarmament Year Book", 1975 [6] while ISS estimates appear annually in "The Military Balance" [7]. Both estimates are similar because of the common estimation method, but SIPRI is the most complete source extending back to 1953 for some countries. A complete spending history of the seven WTO countries is available from 1960-1974 for SIPRI and 1965-1977 for ISS. However, obvious inconsistencies are present in the ISS data for all WTO countries. This result is due to a failure to correct previous estimates when new information becomes available in later years. At most, the previous two years are adjusted and this causes obvious gaps in the data which cannot be explained. Table II shows some examples of the inconsistencies that result when the complete data base is not updated as new information is made available. In the case of Bulgaria, ISS estimates are missing for 1971-1972. Czechoslovakia shows a major increase in defense spending (92%) from 1966-1967 and a major drop from 1971-1972 (47%) which is not supported by either the SIPRI or ACDA data in the same years. The GDR and Hungary have no similar discrepancies but demonstrate the number of changes made in later

TABLE II

SAMPLE ISS MILITARY SPENDING INCONSISTENCIES**

(Current $ Mil)

Bulgaria

	ISS	SIPRI
1970	279	279
1971	---	305
1972	---	337
1973	301/316/352	364
1974	345/403	416

Czechoslovakia

	ISS	SIPRI
1965	715	1191
1966	754	1275
1967	1452	1457
----	---	----
----	---	----
1970	1635	1755
1971	--/1875	1876
1972	1274	2012
1973	1336/1564	1976
1974	1384/1602	2035

GDR

	ISS	SIPRI
1971	2124	2124
1972	2240/1854	2242
1973	2031/2032/2218	2457
1974	2171/2373	2625

Hungary

	ISS	SIPRI
1971	---/543	570
1972	558/419	543
1973	695/424/442	567
1974	457/447/477	611

Poland

	ISS	SIPRI
1970	2220	2244
1971	----/2350	2367
1972	----/1770	2481
1973	1779/1890/1718	2463
1974	2073/1832	2839

Rumania

	ISS	SIPRI
1971	798	787
1972	725/453	818
1973	528/577	840
1974	572/626	910

**The first ISS value in a series indicates the original estimate; the revised estimate follows, separated by /.

years, and the failure to apply the corrective action to all the estimates. For example, in the case of the GDR, 1971 spending was $2124 mil and 1972 initially estimated at $2240 mil, but this is revised to $1834 mil in 1973. So what conclusion can be reached, was there a current spending increase (and the revision of 1973 not applicable to 1971) or a current spending decrease? Similar problems of inconsistency in Poland and Rumania also occur.

This problem with the ISS data should not cause great difficulties because the SIPRI data is an analogous data source that is free of the obvious inconsistencies. Hence, we can reject the ISS data for general use as a data base, and use SIPRI without any serious loss.

Thus, the analysis will be supported by two distinct data sources (i.e., for military expenditures), ACDA and SIPRI. That each can be criticized in areas previously discussed only points toward the need for more research in the Eastern European area. However, in spite of the imperfections in the data, both sources can be useful in uncovering those factors most strongly affecting the decision process in WTO defense budget formulation. This can be done by utilizing a method of parallel analyses, where one data source is used to corroborate the results of the other. Hence, the spurious conclusions arising from the peculiarities of individual sources can be surpressed, while the underlying truth is allowed to surface.

III. CROSS-SECTIONAL ANALYSIS

A. INTRODUCTION

The analysis of cross-sectional variables provides a means of making snap-shot comparisons between selected time periods across the seven WTO countries using a given set of environmental conditions. The selection of two specific years enables a comparison over time which can be helpful in identifying a trend in the effect produced by the underlying influences. The two years selected are 1966 and 1974. 1966 is used as a representative sample of the early years (prior to the invasion of Czechoslovakia in 1968) while 1974 represents the most recent years (post Czech 1968). Both years were relatively uneventful hence free of any unusual or isolated influences.

The initial effort of the cross-sectional analysis is to prepare a variable set hypothesized to explain the spending patterns observed in the aggregate of WTO countries. Then correlation and regression analysis can be applied to rank the explanatory variables in order of importance and provide predictive models for the "typical" WTO country.

1. Variable Set

The basic motivation in defense spending is security of the homeland. The variables listed below suggest various principles given consideration when the strength and capability

requirements of a defense force are determined by defense policy-makers.

a. Gross National Product (GNP)

The economic wealth of a country will likely influence the size of the defense budget. Countries with strong economies and sizeable GNP's tend to invest not only in defense capability, but also in offensive capability as a deterrence to unfriendly neighbors or to satisfy aggressive designs.

b. Population (POP)

Countries with larger populations require greater defense allocations to provide minimum security for greater numbers of persons and property.

c. Border Length (AREA)

Countries with long borders need larger defense forces to repel invaders. Border length will be represented by a similar variable, area, assumed to be highly correlated and hence a suitable substitute.

d. Number of Military Personnel (NMILT)

The larger the size of the Armed Forces the larger the defense budget. This variable is essentially a pseudo-variable and its use can be questioned as its value undoubtedly is a direct result of the defense budget. However, the intention is to see what role personnel costs play in the decision process. If a salaried armed force generates substantial fixed costs then NMILT should be prominent, indicating far less

flexibility for planners in other budget categories (i.e., personnel costs may act as a constraining mechanism on procurement, new facilities, RDT & E, etc.). Such a situation exists in NATO nations where the defense forces are filled by volunteer or mixed conscript-volunteer recruiting systems which command salaries comparable to the civilian work force. Conversely, in the WTO nations where conscription is universal and minimal wages are paid, the personnel costs would not appear to exhibit the same constraining effect. The appearance of NMILT in the WTO model would refute this last statement and imply that personnel costs do indeed significantly constrain WTO budgetory spending (i.e., in the SIPRI model only, recall that ACDA MX applied U.S. salary scales to NMILT so it may appear in the model without implying a significant constraining influence).

B. WTO (1966, 1974)

The WTO data for 1966 and 1974 is listed in Appendix B. Both ACDA and SIPRI military expenditure data will be used in parallel analyses and the results compared.

Correlations and Regression analysis cannot reasonably be applied to the raw data because of the lack of linearity and difference in magnitude with the USSR and the other WTO countries. Thus, if we expect to use least squares regression, it is necessary to first transform the data so that it is more linear. A logarithmic transformation was applied to the data

and the plots for 1966 in Appendix B-3 show a suitable linear relationship between the variables.

The correlation matrices for 1966 and 1974 are shown in Table III. Very high correlations are present as a result of the log transformation. Clearly with such a small sample size (seven data points) the inference limitations of correlation and regression analysis are significant. Wallenius [8] discusses the sample size problem and suggests computing the mean and variance of the coefficient of determination (r^2) as an indication of the amount of spurious correlation present. The calculation of μ_{r^2} and σ_{r^2} is based on a sample size N from a (K+1)-dimensional multivariate normal distribution in which the explanatory variables have no predictive relation with the dependent variable. The result is

$$E[r^2] = \mu_{r^2} = \frac{K}{N-1}$$

$$VAR[r^2] = \sigma_{r^2} = \frac{2\mu_{r^2}(1-\mu_{r^2})}{N-1}$$

Thus μ_{r^2} and σ_{r^2} indicate the mean and variance for the r^2 statistic based on sample size and the number of explanatory variables. This allows a statistical test of the significance of the r^2 statistic found in the regressions. Table IV shows the results of regressions performed on the 1966 and 1974 data.

Both Tables III and IV show GNP having the highest correlation with region-wide WTO defense spending. Population or number of military personnel rank next with area ranked fourth.

TABLE III

WTO VARIABLE SET CORRELATIONS USING LOGARITHMIC TRANSFORMATION

1966

	GNP	POP	Area	NMILT	AMX	SMX
GNP	1.0					
POP	.978	1.0				
AREA	.932	.972	1.0			
NMILT	.926	.954	.988	1.0		
AMX	.980	.976	.975	.980	1.0	
SMX	.995	.972	.935	.943	.986	1.0

1974

	GNP	POP	Area	NMILT	AMX	SMX
GNP	1.0					
POP	.985	1.0				
AREA	.949	.974	1.0			
NMILT	.960	.969	.988	1.0		
AMX	.986	.969	.965	.982	1.0	
SMX	.991	.956	.911	.957	.980	1.0

TABLE IV

REGRESSION RESULTS WTO 1966, 1974

Model	r^2	μ_{r^2} / σ_{r^2}	P*	SER	F	t	Beta
1966							
log MXA = -2.409 + .618 log GNP + .688 log NMILT	.9968	.33 .27	.0068	.0142	632.58	t_1=6.851 t_2=6.796	B_1=.511 B_2=.507
log MXS = -7.48 + 1.423 log GNP	.9904	.167 .215	.00005	.1917	517.9	t_1=22.76	B_1=.995
1974							
log MXA = -2.176 + .67 log GNP + .558 log NMILT	.9887	.33 .27	.0073	.193	174.98	t_1=2.911 t_2=2.35	B_1=.555 B_2=.449
log MXS = -7.054 + 1.335 log GNP	.9819	.167 .215	.00007	.2437	271.67	t_1=16.483	B_1=.991

P* indicates the probability of r^2 at least as extreme as shown, occurring by chance. This value is obtained by consulting Standard Normal Tables with Z calculated as follows:

$$Z = \frac{r^2 - \mu_{r^2}}{\sigma_{r^2}}$$

The difference in the regression equations between the ACDA and SIPRI data shows the effect of direct costing for Personnel Pay and Maintenance. The NMILT variable is significant in the ACDA model but not in the SIPRI model, thus fixed personnel costs are not a significant constraining influence. The very high r^2 values, significant at the .01 level (see low P* values in Table IV) demonstrate the effectiveness of the log transformations in introducing linearity into the variable set.

The significance of the result is that GNP more than any other factor determines the size of the defense budget (however, area and population are not insignificant). Only minor differences occur in the models over time so some confidence in estimating military spending for the typical WTO country in terms of ACDA or SIPRI methods is present.

C. RATIO VARIABLES

Section III-B concluded that GNP was the most significant explanatory variable in the variable set. Further analysis is possible using various ratios from the variable set, thus enabling a characterization of individual countries over the two years selected. The ratios selected are MX/GNP, GNP/POP and NMILT/GNP, which can be categorized as follows:

MX/GNP - a measure of the economic burden of the defense budget on the domestic economy.

GNP/POP - a measure of the general wealth of the country and hence the ability to purchase defense programs.

NMILT/POP - a measure of the militarization of the country with NMILT representing not only force size but also equipment and facilities.

The ratio variables for 1966 and 1974 are listed in Tables V and VI. It should be noted that the sources producing MX estimates by direct costing, specifically the ACDA, caution against the use of MX and GNP together. For example,

> "It should be noted that estimates of Soviet GNP are expressed in a kind of dollar equivalent that is derived from complex valuation of Soviet and U.S. GNP in both rubles and dollars. These dollar equivalents differ from those used to value Soviet Military expenditures in terms of cost to duplicate in the U.S. Thus, these GNP estimates are not comparable to the military expenditure estimates" [6],

and furthermore,

> "The GNP data for other Warsaw Pact countries... ...reflect the same type of hybrid dollar equivalent valuations as used for Soviet GNP. For these countries also, dollar estimates for military expenditures are not directly comparable to the estimates of GNP in hybrid dollars." [6]

SIPRI does not use different dollar equivalent measures in estimating military expenditures and national income, so a suitable ratio can be found using SIPRI estimated Net Material Product (NMP)[1].

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[1]Net Material Product is the measure Eastern European countries use to represent National Income. Unlike GNP in the West, NMP excludes the value (for labor) received in certain personal service areas.

TABLE V

SELECTED RATIOS (WTO 1966)

	MX SIPRI/NMP [17] (%)	Rank	GNP/POP ($)	Rank	NMILT/POP (Troops/100)	Rank
Bulgaria	3.3	5	911.6	6	1.89	1
Czechoslovakia	5.5	2	1676.1	1	1.54	2
GDR	3.7	4	1649.1	2	.72	7
Hungary	2.8	6	1147.1	4	1.06	4
Poland	4.4	3	1060.3	5	.82	6
Rumania	---	-	869.1	7	1.04	5
USSR	6.5	1	1556.6	3	1.36	3
Mean	4.36		1266.98		1.2	
Standard Deviation	1.4		350.8		.42	

TABLE VI

SELECTED RATIOS (WTO 1974)

	MX SIPRI/NMP [17] (%)	Rank	GNP/POP ($)	Rank	NMILT/POP (Troops/100)	Rank
Bulgaria	3.5	5	2235.0	6	1.75	1
Czechoslovakia	4.7	3	3272.1	2	1.38	3
GDR	6.5	1	3544.4	1	.85	6
Hungary	2.8	6	2238.1	5	.98	4
Poland	3.7	4	2261.1	4	.91	5
Rumania	---	-	2061.9	7	.81	7
USSR	5.3	2	3162.7	3	1.4	2
Mean	4.42		2682.19		1.15	
Standard Deviation	1.35		616.65		.36	

The results in Tables 5 and 6 are displayed graphically as deviations from the WTO mean in the histograms in Figures 1 and 2. The most significant result is the change in MX/NMP from 1966 to 1974 by the GDR moving from fourth (below WTO mean) to first. Of the remaining countries, Czechoslovakia, Poland and USSR dropped in rank (with Poland going from above to below the WTO mean) while Bulgaria and Hungary remained unchanged. The change in GNP/POP shows the GDR overtaking Hungary but still well below the WTO mean. Bulgarian and Rumanian GNP/POP improved but they still remain the poor-cousins in the WTO. The NMILT/POP shows sizeable improvement in the GDR while Rumania dropped considerably. Bulgaria remained the most militarized country while the remaining countries all held similar positions as in 1966.

The results of Tables 5 and 6 and Figures 1 and 2 show the GDR rapidly increasing its share of the military burden which together with the Czechs and Soviets are carrying an above average load in defense spending. These three countries are the economic leaders as well but the GDR has not yet reached the per capita troop strength of the other two leaders. Hungary, Poland and Rumania are consistently below the mean while Bulgaria exceeds the mean only in per capita troop strength.

D. CONCLUSIONS

1. GNP is the most important factor in the defense budget decision process. The predictive models for 1966 and 1974 are

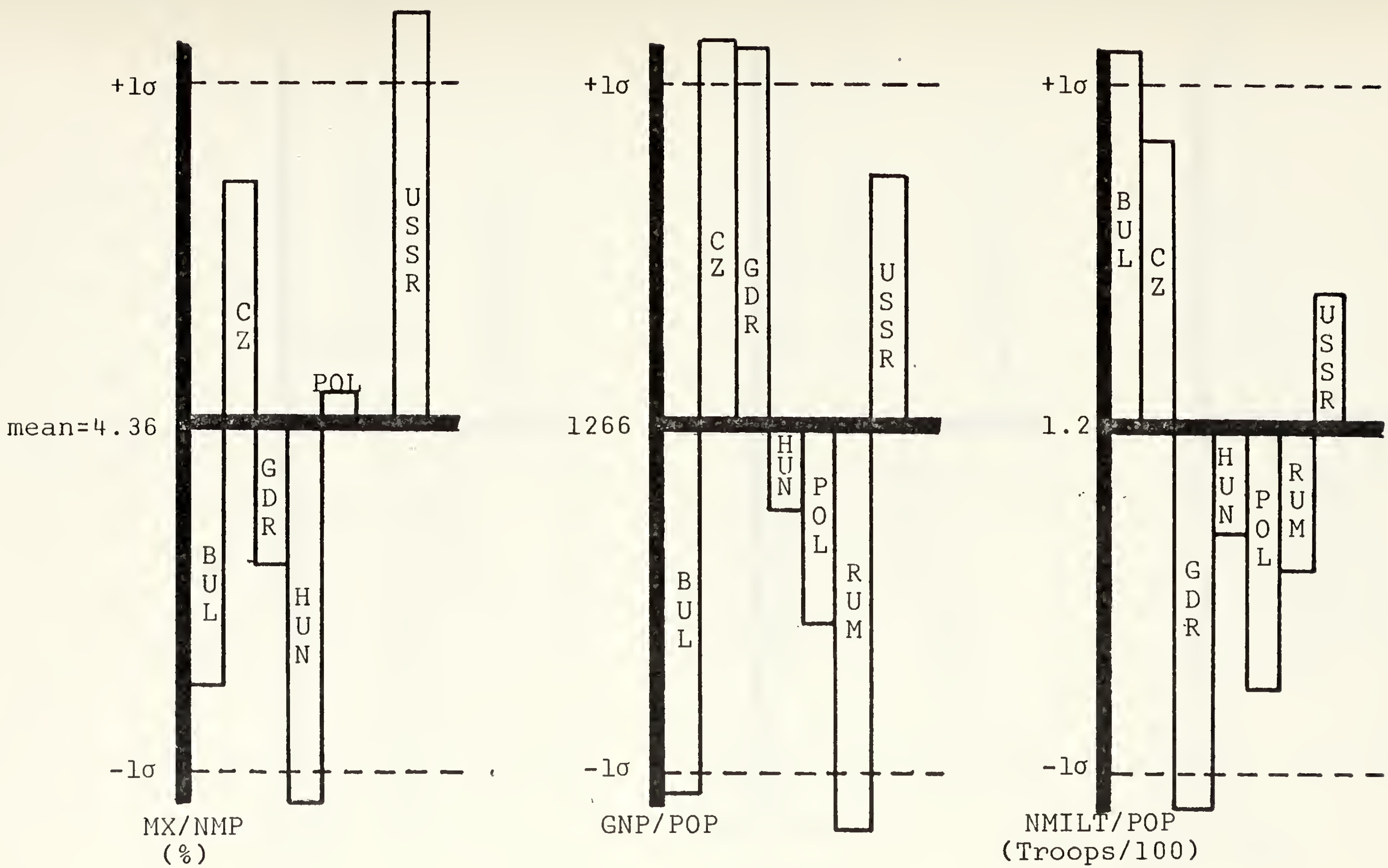

FIGURE 1

WTO 1966 RATIO VARIABLE HISTOGRAMS

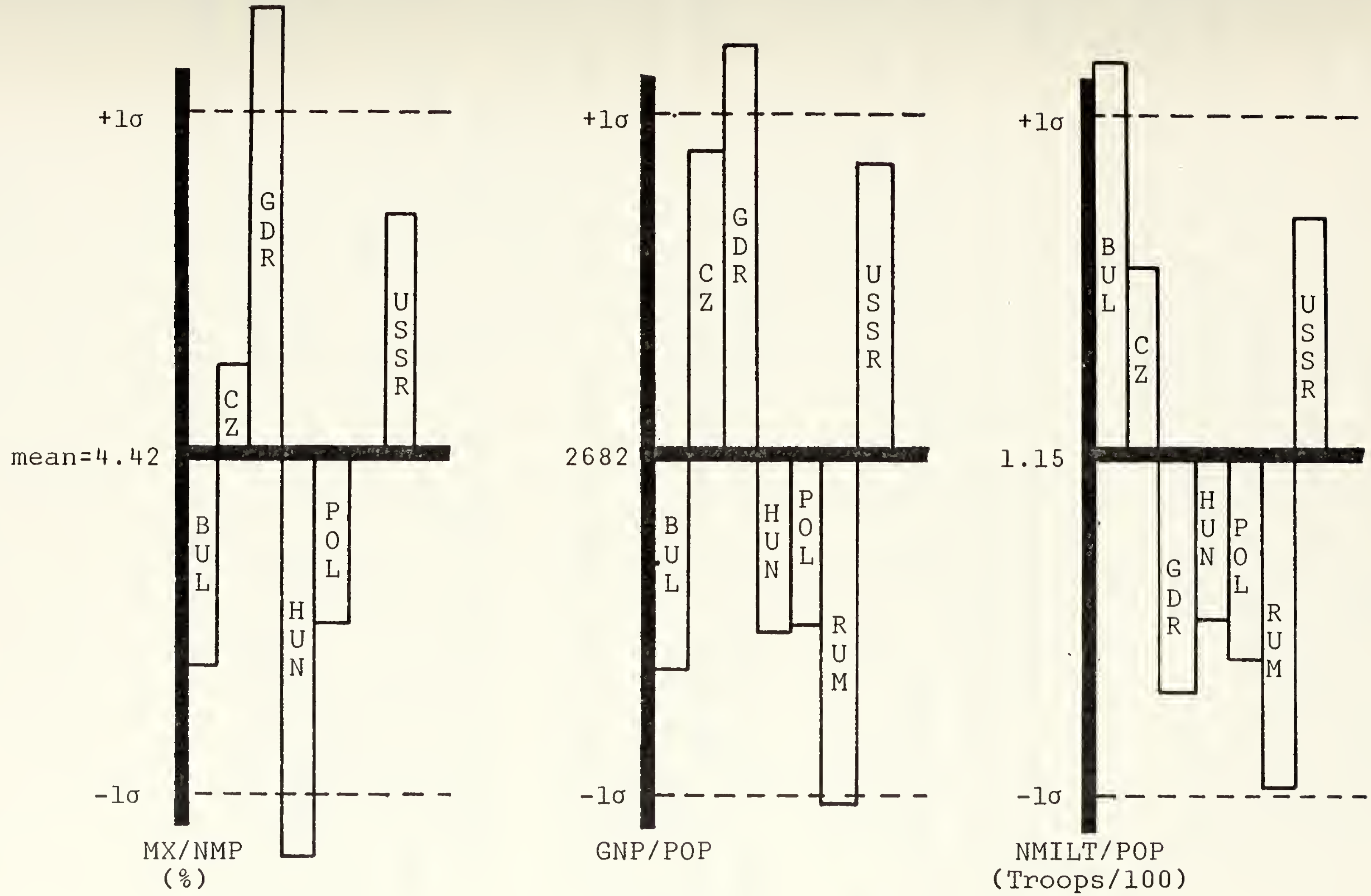

FIGURE 2

WTO 1974 RATIO VARIABLE HISTOGRAMS

not significantly different. The number of military personnel is present as a factor in ACDA models because of the direct costing estimation technique but not in the SIPRI model Thus, personnel costs, while not insignificant, do not play a major role in the budget process.

2. Rankings in absolute spending have remained constant except for the GDR which is now out-spending Czechoslovakia. The same result is true in military expenditures per NMP where the GDR has moved from fourth to first. MX/NMP above the mean - CZ, GDR, USSR; NM/NMP below the mean - BUL, HUN, POL. Rumania NMP is not available.

3. Rankings in absolute GNP (constant $ 1970) remained constant over the period with the per capita GNP leaders Czechoslovakia, GDR and USSR. Bulgaria had the largest gain in per capita GNP pulling close to Hungary and Poland while Rumania still ranks well behind.

4. Rankings in force size shows absolute increases in the GDR, Poland and the USSR while other countries decreased (BUL - 2.6%, CZ - 10%, HUN - 5.8%, RUM - 17.5%). Bulgaria, Czechoslovakia and the USSR remain the per capita force leaders while both the GDR and Poland improved, but still remain below the mean. Rumania dropped from rank five to rank seven.

IV. LONGITUDINAL ANALYSIS

A. PURPOSE AND BACKGROUND

The purpose of the longitudinal analysis is to investigate the conformity or deviance in defense spending policy of WTO member countries vis-à-vis the Soviet Union. This is accomplished by computing the degree of association over time between member country military spending and that of the Soviet Union, other WTO nations and various military and economic factors. Such a methodology enables a systematic study of both region-wide influences, and those characteristic of a specific country. The analysis will focus on the period 1960-1974, a broader and more recent time frame than that of other studies [Kintner and Klaiber 1956-1968, Linden 1965-1969] and employs both parametric and non-parametric methods of statistical inference in the testing of hypotheses and the developments of forecasting models.

Related studies have been published by Kintner and Klaiber [9] and Linden [10]. Both works concentrated on region-wide conformity and foreign policy deviance from the Soviet Union by East European countries (i.e., WTO members plus Yugoslavia and Albania). Each author constructed an index of conformity (or reverse deviance) which purported to represent an ordinary measure of WTO conformity to Soviet-dictated policy in the international sphere. Thus, with the conformity index, the testing of various hypothesized relationships was possible using

Spearman and Kendall correlation coefficients. A brief description of the index construction technique used by each author is found in Appendices C and D.

The data base, spanning approximately 30 variables, is listed in Appendix B, showing variable name definitions, sources and the raw data. Where the data values were measured in U.S. dollars, the GNP Implicit Price Deflator was used to convert current dollars into constant 1970 dollars.

B. TESTING FOR REGION-WIDE INFLUENCES

To uncover the factors underlying the degree of deviance from Soviet set defense policy, it is first necessary to construct an index which will give some measure of conformity in WTO defense spending over the 1960-1974 time frame. Such an index can be constructed by computing the Pearson correlation between the individual WTO MX variable and the USSR MX, and then ranking each country from highest to lowest. Table VII shows the Pearson correlations for each country using the two MX data sources. The rank orderings can now be used as conformity indices for each data source (ACI-ACDA Conformity Index, SCI-SIPRI Conformity Index). Thus the index representing conformity to the USSR in defense spending policy is based on the assumption that Soviet military expenditures are the model to be emulated by the European WTO members. The adherence to the trend set by Soviet MX over time is what is expected of the WTO membership and failure to do so is defined as deviance from the Soviet line.

TABLE VII

PEARSON CORRELATIONS WITH USSR MX 1960-1974

MX	ACDA	Rank	SIPRI	Rank	ACI	SCI	Rank
Bulgaria	.875	5	.618	6	POL	GDR	1
Czechoslovakia	.942	3	.799	4	GDR	POL	2
GDR	.982	2	.959	1	CZ	RUM	3
Hungary	.907	4	.766	5	HUN	CZ	4
Poland	.987	1	.955	2	BUL	HUN	5
Rumania	.599	6	.924	3	RUM	BUL	6

The degree of association between the various ordinal indices can be computed using Spearman and Kendall rank order correlations. All Spearman correlation coefficients (r) and Kendall correlation coefficients (τ) are computed with a specified level of significance. The level of significance is used to test the following hypothesis:

H_o: The correlation coefficient computed is not significantly different from zero.

H_1: The correlation coefficient computed is significantly different from zero (i.e., accept the computed r or τ as being a true measure of correlation).

To use the level of significance the analyst must first make a decision as to how certain he is in accepting or rejecting H_o. If H_o is rejected when in fact it is true, a Type I error has been committed. The probability of committing a Type I error is given by α. That is,

$$P(\text{Type I error}) = \alpha.$$

The larger α is the more likely it is that H_o will be rejected falsely. The decision made by the analyst is in the size of α. If he wants to be 99% sure of his result an $\alpha = .01$ is selected, if he only wants to be 80% sure an $\alpha = .20$ is selected. The α value should always be set prior to collection of the data. After the correlation coefficient has been computed the α value is compared with the level of significance. If the level of significance is less than or equal to α, H_o can be rejected. For the purpose of this thesis α is set equal to .20 meaning that there is a 20% chance that H_o was rejected falsely. The $\alpha = .20$ was selected because of the small sample size ($N = 6$) and also because the data is made up of crude and imperfect estimates. An $\alpha = .20$ gives a general idea of the trend of the data while still giving the obvious disassociations the power to prevent acceptance of erroneous results.

All Spearman and Kendall correlations were computed using the Statistical Package for the Social Sciences (SPSS) [11]. The initial test performed computed the correlation between the ACDA Conformity Index (ACI) and the SIPRI Conformity Index (SCI).

This is necessary because to proceed with a parallel analysis the two indices must have some measure of agreement. The hypothesis tested is

H_o: There is no relationship between the ACI and SCI (i.e., the correlation coefficient is not significantly different from zero).

H_1: There is a relationship between the ACI and SCI.

$\alpha = .20$

Results: Spearman correlation $r = .600$ at .104 level of significance.

$.104 \leq .200 \Rightarrow$ reject H_o

Kendall correlation $\tau = .467$ at .094 level of significance.

$.094 \leq .200 \Rightarrow$ reject H_o

The results imply that the ACI and SCI are in fact related suggesting a reasonable preference to accept the contention that each index represents a rank ordering of the same phenomenon. However, both r and τ appear to be low. A visual comparison of the two indexes points to an obvious discrepancy in the case of Rumania. ACI ranks Rumania sixth while SCI ranks Rumania third. The blatantly dissident behavior of Rumania over the time period and the rank of third assigned in the SCI causes some suspicions to arise over the validity of the Rumanian SIPRI data. These doubts will be investigated more fully in later sections. In spite of this, the ACI and SCI can be used to test region-wide influences on defense spending.

1. <u>Trade Dependence on the USSR</u>

The first factor hypothesized to influence member country defense spending is trade dependence on the USSR. The Soviet Union remains an important supplier of certain essential raw materials, energy resources and some advanced technology to the Eastern bloc. There is no doubt that restriction of trade by the USSR could be used as a means of inducing a recalcitrant pact member into pursuing a defense policy more acceptable to the USSR. An index incorporating East European trade dependence on the USSR can provide a measure of the power available to the USSR to insure alliance conformity. The Trade Conformity Index (TCI) used is identical to that used by Kintner and Klaiber [9] and Linden [10]. It ranks mean percentage of trade with the USSR over the 1960-1974 time period. The result is shown in Table VIII. It should be noted that the TCI remains unchanged if mean percentage trade with the USSR plus WTO countries is measured either over the full time period or are computed for more recent years (i.e., last five years only).

The following hypothesis can now be tested using the TCI, ACI and SCI. If the level of significance is less than or equal to $\alpha = .20$ we will reject H_o.

H_o: There is no relationship between trade dependence on the USSR and conformity to USSR defense policy.

H_1: There is a relationship between trade dependence on the USSR and conformity to USSR defense policy.

TABLE VIII

TRADE CONFORMITY INDEX (TCI)

	BUL	CZ	GDR	HUN	POL	RUM
% of trade USSR	52.5	34.2	41.4	34.1	32.8	31.7
Rank	1	3	2	4	5	6

Results: $r_{ACDA} = .0857$ level of significance = .436

$.436 \nleq .200 \Rightarrow$ accept H_o

$r_{SIPRI} = -.3143$ level of significance = .272

$.272 \nleq .200 \Rightarrow$ accept H_o

$\tau_{ACDA} = .0667$ level of significance = .425

$.425 \nleq .200 \Rightarrow$ accept H_o

$\tau_{SIPRI} = -.200$ level of significance = .287

$.287 \nleq .200 \Rightarrow$ accept H_o

This result is contrary to that of Kintner and Klaiber [9] who found trade dependence related to their Conformity Index ($\tau = .52$ with a significance at the .068 level). It should be noted that the authors included Yugoslavia in their index. This introduces a bias as Yugoslavia is known to be more deviant than other Eastern European countries. If the Kintner and Klaiber results are replicated without Yugoslavia then $\tau = .276$ at .222 significance. This result would require acceptance

of H_o using an α = .20. Linden [10], testing the same hypothesis with his Index of Deviance, also finds no significant relationship between trade dependence and conformity to Soviet Policy.

2. Level of Economic Development

The question of socioeconomic levels in Eastern Europe is an interesting one to consider. Would we find that the higher the economic development of a country the more interaction it would have with the West and thus the less significant would be the influence of the USSR; or would there be an increased fear of economic disruption by the USSR if it strayed too far from the Soviet line? This factor can be tested as it relates to defense spending by measuring the degree of association between the ACI (ACDA Conformity Index) or SCI (SIPRI Conformity Index) and some index of economic development. A meaningful yet simple index of economic development can be constructed by ranking the mean GNP per capita. Table IX shows the EDI (Economic Development Index) based on the GNP per capita tables in Appendix B.

TABLE IX

ECONOMIC DEVELOPMENT INDEX (EDI)

	BUL	CZ	GDR	HUN	POL	RUM
Mean GNP/POP	1192.8	2112.6	2127.9	1413.3	1307.1	1107.2
Rank	5	2	1	3	4	6

The following hypothesis can now be tested:

H_o: There is no relationship between economic development and conformity to USSR set defense policy.

H_1: There is a relationship between economic development and conformity to USSR set defense policy.

$\alpha = .20$

Results: $r_{ACDA} = .6571$ level of significance = .078

$.078 \leq .20 \Rightarrow$ reject H_o

$r_{SIPRI} = .3714$ level of significance = .234

$.234 \not\leq .20 \Rightarrow$ accept H_o

$\tau_{ACDA} = .600$ level of significance = .045

$.045 \leq .20 \Rightarrow$ reject H_o

$\tau_{SIPRI} = .333$ level of significance = .174

$.174 \leq .20 \Rightarrow$ reject H_o

This result shows a significant relationship between economic development and conformity for the ACDA index while it is somewhat inconclusive for the SIPRI index. Kintner and Klaiber [9] using a more complex socioeconomic index found they could reject H_o with a $\tau = .57$ at a significance level of .031. Linden using the GNP per capita index versus the deviance index also rejected H_o with an $r = .857$ at less than .01 significance. These results are supportive of the ACDA index and tend to imply subjectively that the SIPRI conformity index is a less accurate measure.

3. Susceptibility to USSR Military Intervention

Military interference in the internal affairs of WTO member countries is a real possibility as evidenced by the

intrusions into Hungary in 1956 and Czechoslovakia in 1968. The vulnerability of each country depends on the size of any Soviet military force stationed in the country or its geographic position relative to the USSR. To construct the index we will rank those countries with Soviet troops according to the size of the troop contingent. Reference 2 ranks 1) GDR - 20 divisions, 2) CZ - 5 divisions, 3) HUN - 4 divisions, and 4) POL - 2 divisions. This breakdown represents the disposition of Soviet troops since 1968 and is based on status-of-forces agreements with the GDR, POL, RUM, HUN signed in 1956-1957 and with CZ in October 1968 [7]. (Notice that the agreement with RUM did not remain in effect and Soviet troops left in 1958.) For those countries without Soviet troops we rank RUM five as it borders the USSR and BUL six as an intrusion into BUL would have to cross either Rumania or Yugoslavia both of whom would likely resist such an action. Thus, the resulting Military Intervention Index (MII) is as follows:

MII

	BUL	CZ	GDR	HUN	POL	RUM
Rank	6	2	1	3	4	5

The following hypothesis can now be tested:

H_o: There is no relationship between vulnerability to USSR military intervention and USSR defense policy.

H_1: There is a relationship between vulnerability to USSR military intervention and USSR defense policy.

$\alpha = .20$

Result: $r_{ACDA} = .600$ level of significance = .104

$.104 \leq .20 \Rightarrow$ reject H_o

$r_{SIPRI} = .5429$ level of significance = .133

$.133 \leq .20 \Rightarrow$ reject H_o

$\tau_{ACDA} = .4667$ level of significance = .094

$.094 \leq .20 \Rightarrow$ reject H_o

$\tau_{SIPRI} = .4667$ level of significance = .094

$.094 \leq .20 \Rightarrow$ reject H_o

This result shows a significant relationship between a country's defense spending policy and its susceptibility to military action by the Soviet Union. Both Kintner and Klaiber [9] and Linden [10] conclude that a similar null hypothesis can be rejected.

Some readers might argue for a higher ranking in the case of Poland because of strong historical and economic ties to the USSR and the nearness of a substantial Soviet military force (20 divisions in the GDR, common border with USSR, etc.). If the MCI were to rank Poland second and slide CZ and HUN one rank, the rank order correlations would improve to the .73-.89 range, giving further support to the importance of military vulnerability in WTO defense policy decisions.

4. Conclusions

a) Trade dependence is not significantly related to conformity to USSR defense policy.

b) Economic development and conformity to USSR defense policy are related but reasonable doubt exists in the case of the SIPRI data.

c) Susceptibility to USSR military intervention and conformity to USSR defense policy have a significant relationship.

C. TESTING SPECIFIC INFLUENCES IN INDIVIDUAL COUNTRIES

The hypothesis testing completed above is useful in identifying the region-wide factors influencing defense policy, but it cannot be used to investigate each country for specific peculiarities existing among the many economic and military factors occuring over time. Given the complexities of the domestic and international interactions that occur in the formulation of a national defense budget, it would be a naive proposition to suggest that one or two factors determine the policy followed. Thus, to use one or two variables in a linear forecasting model is not to imply that only these factors determine a country's spending decisions, but rather that the explanatory variables result in the smallest variance possible in a forecasting model. These variables carry the <u>explanatory effect</u> of other important variables (whose estimators may not be significantly different from zero when regressed together) into the linear equation.

The aim of the analysis will be to identify those factors most closely associated with the military spending of each country over the 1966-1974 time period. We will consider the

military expenditures of NATO (NATOT - Total NATO, NAEXC - Total NATO less U.S., and NAEUR - Total NATO European) as well as those for the USSR, and neighboring countries both in the Eastern and Western alliances. In addition, certain economic factors will be considered such as GNP, trade (TRATOT - Total trade, TRAUSSR - Total trade with USSR, TRAEE - Total trade with other WTO nations less USSR, and TRAWEST - Trade with the West[2]) and Balance of Payments (BPTOT, BPUSSR, BPEE and BPWEST). Those variables moving with a country's military expenditures over time should produce high correlations thus providing a clue as to what factors might weigh most heavily on the policy actions observed. Those factors with the highest correlations can then be nominated as candidates for inclusion in the forecasting model which is constructed using a step-wise regression.

Due to similarities in many of the variables, multicollinearity can become a problem. Therefore we will not nominate two variables of the same class highly correlated with each other (e.g., NAVEUR and NAEXC) for inclusion in the step-wise regression. In addition, variables highly correlated with the subject country's MX, but for which no substantive interactive relationship is expected (e.g., between Poland and Portugal) will not be considered.

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[2]The Western countries considered are Austria, BENELUX countries, Canada, Denmark, Finland, France, W. Germany, Greece, Italy, Norway, Sweden, Switzerland, United Kingdom and U.S.A.

In each regression a group of statistics is generated to help determine the suitability of the model. The following is a brief description of each:

r^2 - the coefficient of determination is a measure of how well the model fits the data. It gives the proportion of total variance accounted for by the model.

t-statistics - the t-statistics, indicated in parenthesis below the coefficient in each regression equation, allow a test of significance on each coefficient estimate. As a general rule if the t-statistic is greater than 1.8 (assuming N = 15, K = 1 or 2) the coefficient can be accepted as significant at the .05 level.

SER - the Standard Error of Regression gives a measure of the standard deviation about the regression line for the model.

F-statistic - the F-statistic allows the entire model to be tested statistically for significance. As a general rule if the F-statistic is greater than 5.0 (N = 15, K = 1 or 2) the model can be accepted as statistically significant.

DW-statistic - the Durbin-Watson statistic is used in conjunction with the analysis of residuals. If structure is detected in the residual a test for serial correlation can be performed using the DW statistic (see Appendix G).

1. <u>Bulgaria</u>

Bulgaria is the southern most country in the WTO alliance bordering Turkey, Greece, Yugoslavia and Rumania. Correlations

for 32 variables with BULMX (including military expenditures for Turkey, Greece and Yugoslavia) were computed. These values using both ACDA and SIPRI data are listed in Appendix E. When examining the individual correlations a subjective approach is used to categorize the correlations as high range (above .900), mid-range (.800-.899) and low range (.799 and below). Thus, the variables can be assigned into three nominal classifications which enables some inference about the importance of individual variables to be made.

a. ACDA

The Bulgarian ACDA rank order correlations are categorized in Table X. The most obvious relationship is the high correlation military spending has with Bulgarian trade with the other WTO members ($TRAEE_t$ = .981) and with the USSR ($TRAUSSR_t$ = .934). Another economic variable $BULGNP_t$(.945) is prominent as well. This result tends to support a contradiction to the hypothesis that trade dependence is not related to defense spending (i.e., in the case of Bulgaria). Also of interest is the high correlations with Turkish ($TURMX_t$ = .978, $TURMX_{t-1}$ = .96) and lagged Greek ($GREMX_{t-1}$ = .902) spending. This result is not unexpected when one considers that Bulgaria, with no USSR troops, would be WTO's first line of defense against a NATO attack from the south (i.e., from Turkey or Greece). Poland is the only Eastern bloc country in the high range. This indicates the defense policy of other WTO nations and the USSR are of less concern than the variables in the high range.

TABLE X

BULGARIAN ACDAMX ($BULAMX_t$)
RANK ORDER CORRELATIONS

High Range

1.	$TRAEE_t$	.981
2.	$TURMX_t$	.978
3.	$TURMX_{t-1}$	.960
4.	$TRATOT_t$	.956
5.	$BULGNP_t$	.945
6.	$POLAMX_{t-1}$	.940
7.	$TRAUSSR_t$	.934
8.	$POLAMX_t$	.921
9.	$GREMX_{t-1}$	.902

Mid-Range

1.	$USSRMX_{t-1}$	.899
	$NAEXC_t$	.899
2.	$NAEUR_t$	.895
3.	$USSRMX_t$	.875
4.	$GDRAMX_{t-1}$	.870
5.	$YUGMX_t$	.866
6.	$CZAMX_t$	.863
7.	$GDRAMX_t$	.862
8.	$NAEUR_{t-1}$	.855
9.	$HUNAMX_t$	.853
10.	$NAEXC_{t-1}$	.852
11.	$HUNAMX_{t-1}$	.850
12.	$FGRMX_t$	.832
13.	$GREMX_t$	.835
14.	$RUMAMX_{t-1}$	.816
15.	$RUMAMX_t$	.808
	$CZAMX_{t-1}$	.808

Low Range

1.	$YUGAMX_{t-1}$	.793
2.	$TRAWEST_t$	.79
3.	$FGRMX_{t-1}$	.754
4.	$BPUSSR_t$	.67
5.	$BPEE_t$	-.616
6.	$BPWEST_t$	-.575

No Correlation

1.	$NATOT_{t-1}$	.367
2.	$NATOT_t$	.211

When the mid-range variables are considered, it is interesting that the NATO (less U.S.) variables stand clustered with the USSRMX variables. The balance of the mid-range variables represent WTO nations with Yugoslavia, Greece and FGR military expenditures. Of least concern are Balance of Payments, Trade with the West and Total NATO spending.

The step-wise regression results in Equation 1 below:

$$\begin{aligned} BULAMX_t &= 408.083 + .274\ BULTRAEE_t + .519\ TURMX_t \\ r^2 &= .9726 \quad\quad (2.719) \quad\quad\quad\quad (2.106) \\ SER &= 25.92 \\ F &= 213.033 \\ DW &= 1.246 \end{aligned}$$

Equation 1

Equation 1 shows Bulgarian ACDA MX explained by Bulgarian trade with other Eastern European countries and current Turkish defense spending. The r^2 of .9726 shows a very good fit with model explaining over 97% of the total variance. Both $BULTRAEE_t$ and $TURMX_t$ coefficients are greater than 1.8 hence significant as is the large F statistic of 213.033. The SER shows the standard deviation about the model to be $25.92 million. Analysis of the residuals shows a lack of structure and serial correlation is not indicated by the DW of 1.246.

b. SIPRI

The Bulgarian SIPRI rank order correlation in Appendix E are lower than those for the ACDA variables. This occurs because of the sharp differences between the ACDA and

SIPRI data. The plot in Figure 3-b shows a large increase-decrease in the SIPRI data over the 1962-1966 time period. It is highly unlikely that such an expansion-contraction could occur over a three year period without accompanying perturbations in one or more of the other variables. Attempting linear regression with $BULSMX_t$ as the dependent variable would not produce a very satisfactory predictive model, but the data may still be useful if the effect of the 1962-1964 disturbance can be minimized or smoothed out. To accomplish this, a running median of three, repeated until convergence smoothing program is used [2]. Figure 3-c shows the results of the smoothing process. The results of smoothing can also be seen in the model improvement that results from the regression. Equation 2 is the model before smoothing while Equation 3 is the smoothed model.

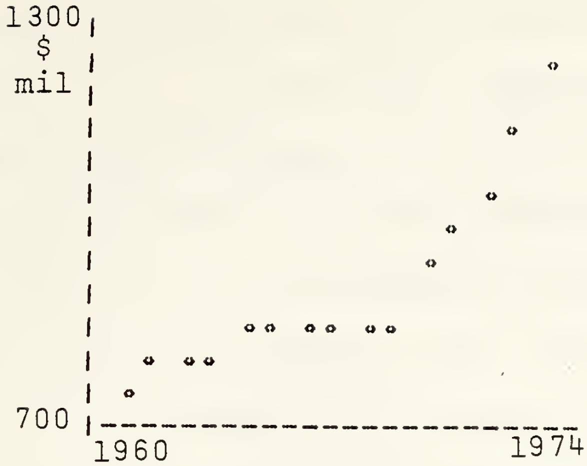
$$BULSMX_t = 54.9774 + .0354\ FGRMX_t$$
$$r^2 = .7298$$

<u>Equation 2</u>

$$BULSMX_t = 7.307 + .023\ FGRMX_t + .203\ YUGMX_t$$
$$r^2 = .8566 \quad (3.7585) \qquad (2.502)$$
$$SER = 14.1274$$
$$F = 35.8470$$
$$DW = 1.241$$

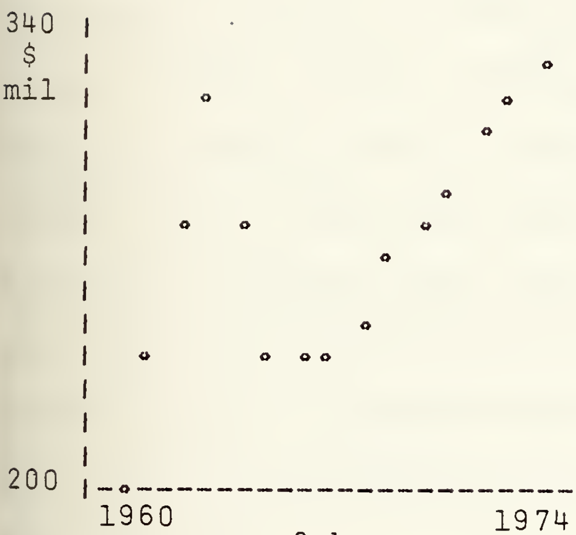
<u>Equation 3</u>

Equation 3 shows smoothed Bulgarian SIPRI spending as explained by current MX for West Germany and Yugoslavia. The



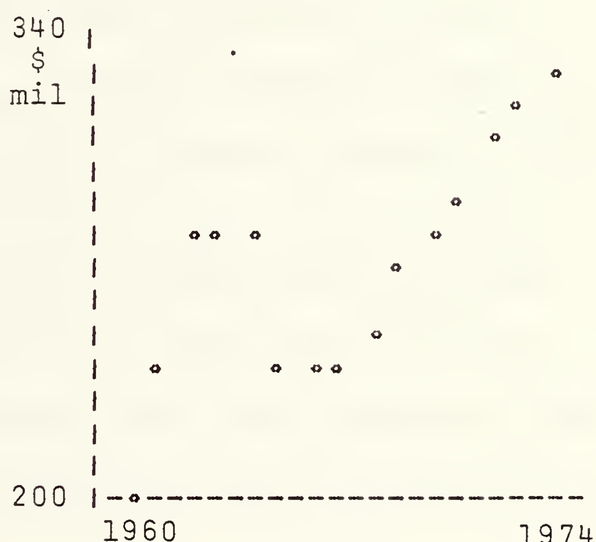
3-a

ACDA



3-b

SIPRI



3-c

SMOOTHED SIPRI

FIGURE 3

BULGARIAN MILITARY EXPENDITURES
(1960-1974)

$r^2 = .8566$ shows the increase from .7298 that occurred by smoothing. Thus, with all coefficients significant over 85% of the total variance can be explained with this model.

In examining the individual correlations some improvement is noted, but it is necessary to redefine the high range to include correlations greater than .800. The mid-range is redefined as .700-.799 while the low range is below .700. Classifying the variable correlations in this manner results in the categories of Table XI.

Some similarities now appear in the correlations between the ACDA and SIPRI correlations. If the top third of each data source is checked (i.e., the first eleven rank order correlations) seven of eleven variables occur in both data sources (TRAEE, $TURMX_t$, $TURMX_{t-1}$, $BULGNP_t$, TRAUSSR, $GREMX_{t-1}$, $NAEXC_t$). Turkish military spending and Eastern European trade (TRAEE) rank in the high range for both data sources. The SIPRI data indicates much lower rank correlations with USSR and other WTO nations than found in the ACDA data. The low ranking given to Rumanian spending, NATO total spending, trade with the West, and Balance of Payments all show similarities with the ACDA.

c. Conclusions

(1) ACDA correlations (with $BULAMX_t$) are higher than SIPRI (with $BULSMX_t$) but show similar high range correlations for trade with Eastern Europe and the USSR, NATO (less U.S.), Turkish and Greek military spending and Bulgarian Gross National Product.

TABLE XI

BULGARIAN SMOOTHED SIPRI MX (BULSMX$_t$) RANK ORDER CORRELATIONS

	High Range			Mid-Range			Low Range	
1.	FGRMX$_t$	.884	1.	YUGMX$_{t-1}$	.783	1.	GREMX$_t$	.691
2.	NAEXC$_t$	.836	2.	BULGNP$_t$	.774	2.	FGRMX$_{t-1}$	.685
3.	NAEUR$_t$	.827	3.	TRAUSSR$_t$	.768	3.	HUNSMX$_t$	.680
4.	YUGMX$_t$	.826	4.	GREMX$_{t-1}$	.763	4.	POLSMX$_{t-1}$	.678
5.	TURMX$_t$	.818	5.	CZSMX$_{t-1}$	.760	5.	HUNSMX$_{t-1}$	.667
6.	TRAEE$_t$	.810	6.	USSRMX$_{t-1}$	.748	6.	POLSMX$_t$	.666
7.	TURMX$_{t-1}$	.801	7.	GDRSMX$_t$	.746	7.	RUMSMX$_{t-1}$	.642
			8.	NAEXC$_{t-1}$	.743	8.	CZSMX$_t$	.574
			9.	NAEUR$_{t-1}$	.739	9.	RUMSMX$_t$	.552
			10.	USSRMX$_t$	.732	10.	TRAWEST$_t$	.539
			11.	GDRSMX$_{t-1}$	.722	11.	BPEE$_t$	-.446
			12.	TRATOT$_t$	.720	12.	BPUSSR$_t$	.394

	No Correlation	
1.	NATOT$_{t-1}$	.344
2.	BPWEST$_t$	-.224
3.	NATOT$_t$	.170

(2) Spending policies of the USSR and other WTO nations give low to mid-range correlations suggesting some measure of defense policy independence from the USSR.

(3) Balance of Payments and Total NATO Military Spending are not related to Bulgarian Military Spending.

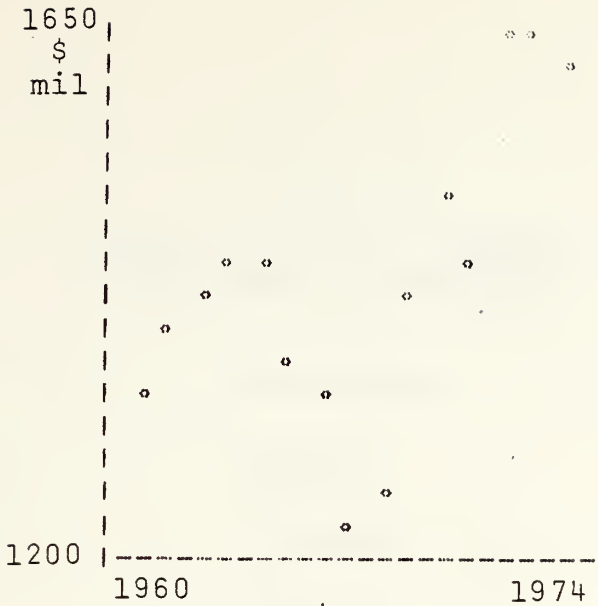
2. Rumania

Rumania is in the Southern Group of the WTO countries bounded by Bulgaria in the south, Yugoslavia and Hungary to the west, and the Soviet Union to the north and Black Sea to the east. Soviet troops were invited to leave Rumania in June 1958 and have been denied transit rights in WTO military exercises ever since [2]. Only recently has Rumania re-entered the WTO fold by participating in joint exercises but there is still reluctance concerning other WTO troops on Rumanian soil [2].

The plots of ACDA and SIPRI military expenditures are shown in Figures 4-a and 4-b. Once more sharp differences between sources are present; however, it is the ACDA data which exhibits the greatest variability over the time period. Performing the median of three and split smoothing routine on the ACDA data results in the plot shown in Figure 4-b. Comparison of the smoothed ACDA and SIPRI plots shows a contradictory pattern over the 1965-1970 time period.

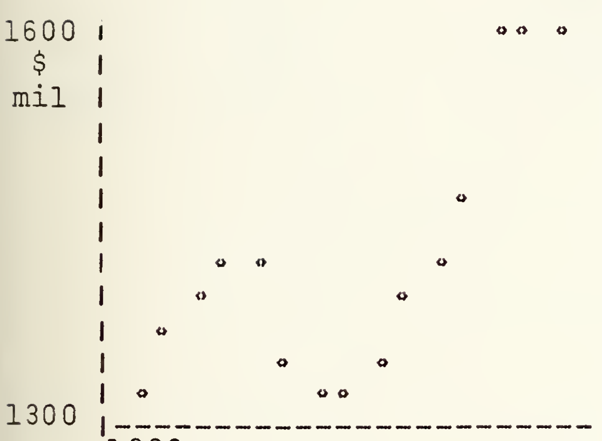
a. ACDA

Correlations for the 31 variables correlated with the smoothed data of Appendix E is classified in Table XII.



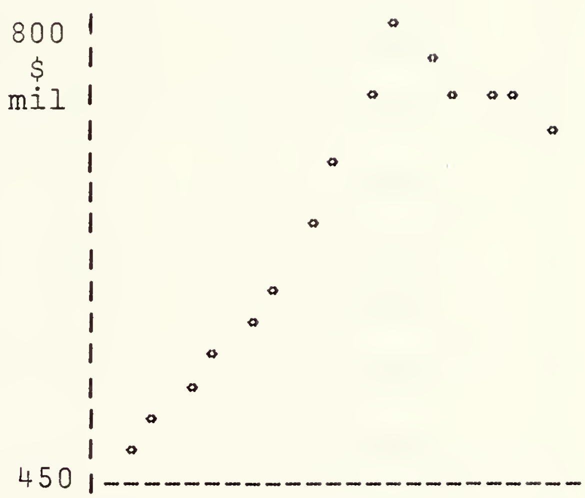
4-a

ACDA



4-b

SMOOTHED ACDA



4-c

SIPRI

FIGURE 4

RUMANIAN MILITARY EXPENDITURES

TABLE XII

RUMANIAN ACDA MX ($RUMAMX_t$) RANK ORDER CORRELATIONS

High Range

1.	$BULAMX_t$	.907
2.	$TRAEE_t$	.901

Mid-Range

1.	$BULAMX_{t-1}$	.852
2.	$TRAUSSR_t$	.848
3.	$TRATOT_t$	.845
4.	$YUGAMX_t$	.842
5.	GNP_t	.837
6.	$POLAMX_t$	.825
7.	$TRAWEST_t$	.821
8.	$POLAMX_{t-1}$	.819
9.	$YUGAMX_{t-1}$	.806

Low Range

1.	$NAEXC_t$	.729
2.	$FGRMX_t$	.785
3.	$NAEUR_t$	.787
4.	$HUNAMX_t$	.781
5.	$USSRMX_{t-1}$	.762
6.	$GDRAMX_{t-1}$	.742
7.	$GDRAMX_t$	.736
8.	$USSRMX_t$	.727
9.	$HUNAMX_{t-1}$	.701
10.	$NAEXC_{t-1}$	.699
11.	$CZAMX_t$	.695
12.	$NAEUR_{t-1}$	.691
13.	$FGRMX_{t-1}$	.620
14.	$CZMX_{t-1}$	.612
15.	$BPUSSR_t$	.521

No Correlation

1.	$BPEE_t$	.237
2.	$NATOT_{t-1}$	.216
3.	$BPWEST_t$	.085
4.	$NATOT_t$	-.01

The spasmodic movement in Rumanian real spending is not strongly related with any of the 31 variables. The economic variables Trade and GNP produce the closest relationship along with Bulgarian spending. Except for $POLAMX_t$ in the mid-range, the remaining WTO countries and NATO have low to no correlation with Rumanian spending.

The step-wise regression produces the model in Equation 4.

$$RUMAMX_t = 1057.417 + .762\ TRAEE_t - .179\ TRAWEST_t$$

$$r^2 = .9084 \quad (5.555) \quad (-3.576)$$

$$SER = 31.45$$

$$F = 59.5373$$

$$DW = 1.288$$

Equation 4

Equation 4 shows Rumanian ACDA MX explained by trade with Eastern Europe and trade with the West. The negative coefficient for $TRAWEST_t$ is significant because it states that Rumania spends less as trade with the West increases. Over 90% of the total variance is explained with all test statistics significant.

b. SIPRI

Correlations for the 31 variables in Appendix E are classified in Table XIII. Comparing Table XII with Table XIII it is immediately obvious that except for Polish MX, a unique inversion of the correlates occurs between ACDA and SIPRI data sources. When the correlations in the two tables are rank ordered and the two sets correlated using the Kendall and

TABLE XIII

RUMANIAN SIPRI MX ($RUMSMX_t$) RANK ORDER CORRELATIONS

High Range

1.	$POLSMX_t$	.977
2.	$POLSMX_{t-1}$	.960
3.	$GDRSMX_t$	.940
4.	$USSRMX_t$	.924
5.	$USSRMX_{t-1}$	.905
6.	$NATOT_{t-1}$	.903

No Correlation

1.	$BPUSSR_t$	.394
2.	$BPEE_t$	.285

Mid-Range

1.	$GDRSMX_{t-1}$	.896
2.	$NAEUR_{t-1}$	.853
3.	$GDRSMX_t$	.852
4.	$NAEUR_{t-1}$	.844
5.	$HUNSMX_t$	.834
6.	$CZSMX_{t-1}$	.829
7.	$NAEUR_t$	.822
8.	$HUNSMX_{t-1}$	.812
9.	GNP_t	.809
10.	$NATOT_t$	.808
11.	$NAEXC_t$	.808

Low Range

1.	$FGRMX_{t-1}$	.687
2.	$TRATOT_t$	.659
3.	$TRAEE_t$	.657
4.	$BPWEST_t$	.655
5.	$YUGMX_{t-1}$	.650
6.	$TRAWEST_t$	.647
7.	$FGRMX_t$	.628
8.	$YUGMX_t$	.611
9.	$TRAUSSR_t$	.562
10.	$BULSMX_{t-1}$	.474
11.	$BULSMX_t$	.438

Spearman methods, no correlation between the two sources is found ($r = .00$ at .5 significance, $\tau = .0048$ at .49 significance). This result causes rejection of the hypothesis that the two sources are observations of the same phenomenon. Thus, we are faced with two diametrically opposed variable sets each in contradiction of the other.

If the step-wise regression is performed, Equation 5 results.

$$RUMSMX_t = -35.7524 + .225\ POLSMX_t + 2.724\ NATOT_{t-1}$$

$$r^2 = .9797 \qquad (9.871) \qquad (3.822)$$

$$SER = 16.7525$$

$$F = 289.4958$$

$$DW = 1.585$$

Equation 5

c. ACDA versus SIPRI

To resolve the contradiction over Rumania between sources, it is necessary to reject one data base in favor of the other. Thus, it is imperative to review the Rumanian relationship with the USSR over the full breadth of the time series.

Some excellent accounts of Rumanian social, economic and political development can be found in Monitas, Pounds, Fischer-Galiti and Floyd [12,13,14,15 and 16]. A fundamental review of post-World War II events in Appendix F points to economics as the key to deviance in Rumania. The second-class citizenship of Bulgaria and Rumania as the producer of foodstuffs and raw materials for the other WTO countries was rejected

by the strongly nationalistic Rumanian leadership as far back as 1949. The Rumanians sought to industrialize as a means of achieving economic independence. This was only possible with increased trade with the West which had the modern technology and industrial equipment. The conflict with the Kremlin that occurred in 1962-1963 over supra-national planning and control of all WTO economies by COMECON resulted in a victory for the Rumanian-led opposition. This followed with a call for national sovereignty and independence and the abolition of military alliances. Since Rumania was not threatening withdrawal from the Warsaw Pact, but only dissolution of all military alliances and was not deviating on ideological grounds domestically, the Soviets found it difficult to justify direct intervention.

Such action shows a country striving for rapid industrial development using scarce Western currency to purchase the most advanced technology. It is unlikely that the steady increase in military expenditures shown by SIPRI would occur if the national policy was conversion from an agrarian to an industrial economy. Recall that SIPRI generally reports the military expenditures as they are officially published while the ACDA data, as estimated by Alton, represents the estimated cost of procurement, operations and maintenance, manpower and R & D. Data available from the ISS on Rumania for the 1964-1974 time period indicates Rumanian troop strength dropped from 222,000 to 171,000 (Appendix B). The fluctuations in troop strength show a pattern similar to the ACDA military

expenditure data. Certainly the reduction in force size does not support the real spending increases shown in the SIPRI data. Hence, a real cause for rejecting the ACDA data cannot be found, in fact the independent assessment of the ISS troop data supports the ACDA data, and casts grave doubts on the SIPRI data. Thus, given the economic aspirations of Rumania, the evidence that sizeable reductions in the defense force occurred in support of this industrialization, and the anti-militarism/peaceful co-existence philosophy espoused in support of national sovereignty, a contradiction to real growth in defense spending as indicated by the SIPRI data is present. Hence, we reject the Rumanian SIPRI data in favor of ACDA and drop it from consideration in subsequent analyses.

d. Conclusions

(1) Rumanian SIPRI data is rejected as unreliable and permanently removed from this and subsequent analyses.

(2) Rumanian military spending is erratic with the highest correlations occurring with Bulgaria and trade with Eastern Europe.

(3) Except for Poland, mid-range correlations do not involve other WTO countries, but contain the remaining trade variables, GNP and Yugoslavian MX.

(4) Rumanian military spending has the lowest correlation with the NATO variables, USSRMX, GDRMX, HUNMX, CZMX, FGRMX and Balance of Payments.

(5) The forecasting model shows a negative coefficient in trade with the West and a positive coefficient with Eastern European trade. Almost 91% of the variance in spending is accounted for in the model (SIPRI model, Equation 5 is rejected).

3. Czechoslovakia

Czechoslovakia is surrounded by WTO nations with the exception of Austria to the south and FGR to the west. Military data on the FGR will be included in the variable set, but we will not consider Austria as it is not a NATO member and has only a minimal defense budget, making it no threat to the WTO. In addition, the USSR has five divisions comprising 70,000 troops permanently stationed in Czechoslovakia and maintains WTO Central Group Headquarters near Prague [2].

a. ACDA

The Czech rank order correlations from Appendix E classified in Table XIV show the NATO (less U.S.) variables most strongly correlated with $CZAMX_t$ ($NAEUR_{t-1}$ = .986, $NAEXC_{t-1}$ = .984, $NAEUR_t$ = .973, $NAEXC_t$ = .969). Following in the high range (greater than .900) are all the WTO members spending variables except Rumania ($HUNAMX_{t-1}$ = .952, $POLAMX_{t-1}$ = .946, $GDRAMX_t$ = .944, $USSRMX_t$ = .942, $GDRAMX_{t-1}$ = .939, $POLAMX_t$=.936, $USSRMX_{t-1}$=.933, $BULAMX_{t-1}$=.917, $HUNAMX_t$=.911). The two lowest variables in the high range are $TRAUSSR_t$ and $FGRMX_{t-1}$ at .909 and .908 respectively. The mid-range correlations (.800-.899) encompasses the trade variables (except $TRAUSSR_t$ which is in

TABLE XIV

CZECHOSLOVAKIA ACDA MX ($CZAMX_t$) RANK ORDER CORRELATIONS

High Range			Mid-Range			Low Range		
1.	$NAEUR_{t-1}$	.986	1.	GNP_t	.887	1.	$YUGMX_{t-1}$	.739
2.	$NAEXC_{t-1}$	.984	2.	$TRAEE_t$	.886	2.	$NATOT_{t-1}$	.648
3.	$NAEUR_t$	.973	3.	$TRATOT_t$	.884	3.	$RUMAMX_{t-1}$	.584
4.	$NAEXC_t$	.969	4.	$FGRMX_t$	.865	4.	$NATOT_t$	.573
5.	$HUNAMX_{t-1}$	.952	5.	$BULAMX_t$	.863	5.	$BPWEST_t$	.541
6.	$POLAMX_{t-1}$	.946	6.	$TRAWEST_t$	.847	6.	$RUMAMX_t$	.53
7.	$GDRAMX_t$	.944	7.	$YUGMX_t$	.839	7.	$BPTOT_t$	.481
8.	$USSRMX_t$	.942						
9.	$GDRAMX_{t-1}$	.939						
10.	$POLAMX_t$	.936						
11.	$USSRMX_{t-1}$	.933						
12.	$BULAMX_{t-1}$	.917						
13.	$HUNAMX_t$	.911						
14.	$TRAUSSR_t$	.909						
15.	$FGRMX_{t-1}$	.908						

No Correlation		
1.	$BPEE_t$	.314
2.	$BPUSSR_t$	.235

the high range), GNP_t and $BULAMX_t$, $FGRMX_t$ and $YUGMX_t$. The low range correlations include the NATO total MX variable, Rumanian MX and Balance of Payments.

The high correlations with the NATO variables implies a Czechoslovakian response to NATO European spending (represented by "order-of-battle" changes, manpower levels, weapons systems, etc.) backed up by her WTO allies (except Rumania). Trade (except $TRAWEST_t$) and GNP_t variables, while still significantly correlated with $CZAMX_t$, have less explanatory effect than the spending policies of Hungary, Poland, GDR, USSR, Bulgaria and FGR.

Performing the regression results in Equation 6 but the DW statistic indicates negative serial correlation.

$$CZAMX_t = 375.294 + 102.294\ NAEUR_{t-1}$$

$$r^2 = .9718 \qquad (21.155)$$

$$F = 447.5493$$

$$DW = 3.145$$

Equation 6

Solving for the coefficient of serial correlation ρ using the Hildreth-Lu grid search and performing the generalized differencing procedure yields the final model in Equation 7.[3]

$$CZAMX^*_t = -663.7387 + 104.0416\ NAEUR^*_{t-1}$$

Equation 7

$$r^2 = .9904 \qquad (35.32)$$

where $\rho = -.589$

$$SER = 38.52 \qquad DW = 2.17$$

$$CZAMX^*_t = CZAMX_t - \rho CZAMX_{t-1}$$

$$F = 127.208$$

$$NAEUR^*_{t-1} = NAEUR_{t-1} - \rho NAEUR_{t-2}$$

---

[3]See Appendix G for discussion of serial correlation/ Hildreth-Lu.

Equation 7 is the final model explained by one variable, lagged NATO European MX. Notice the difference in the model after the generalized differencing procedure is applied. To forecast a value for $CZAMX_t$ it is necessary to solve for $NAEUR^*_{t-1}$ as shown using $\rho = -.589$. The final result $CZAMX^*_t$ is then used as follows to obtain the predicted value $CZAMX_t$.

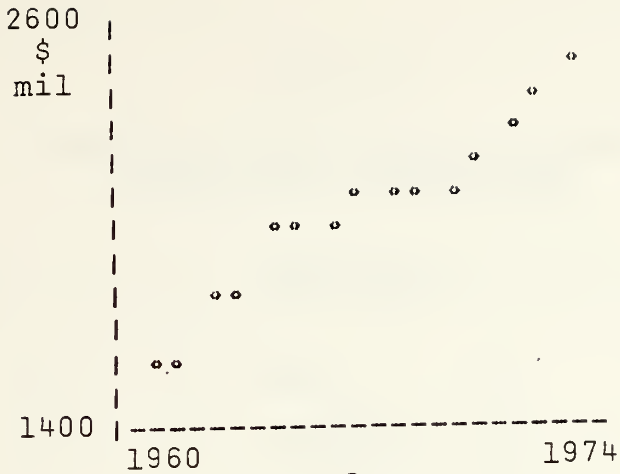
$$CZAMX_t = CZAMX^*_t + \rho CZAMX_{t-1}$$

Also noteworthy is the slight improvement in r^2 from .9718 to .9904. All summary statistics are significant and no structure is noted in the residuals.

b. SIPRI

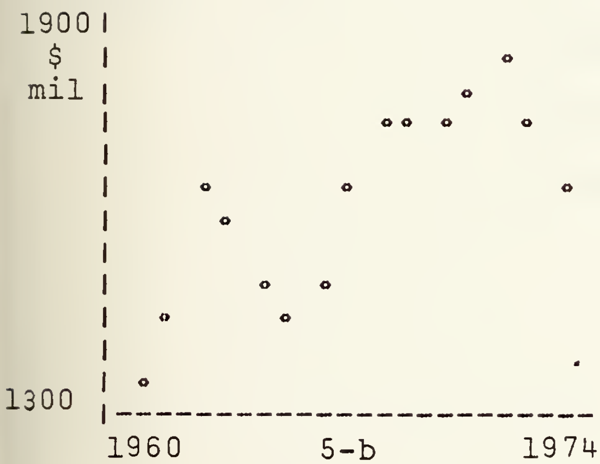
The SIPRI rank order correlations in Appendix E show a similar phenomenon to that of Bulgaria (except Rumanian data omitted as a result of the analysis in Section IV) The SIPRI correlations are much lower because of sharp increases-decreases not evident in the ACDA data. Figure 5-a and 5-b show the contrast between the two while Figure 5-c shows SIPRI data after the smoothing routine is applied. The correlations for the smoothed data are displayed in Table XV with high range (.800 and above), mid-range (.600-.799) and low range (below .600).

Unlike the Bulgarian SIPRI data, fewer similarities occur between the two data sources. The smoothing routine was able to minimize the short term increase-decrease phenomenon, but it could not correct the basic difference occurring from



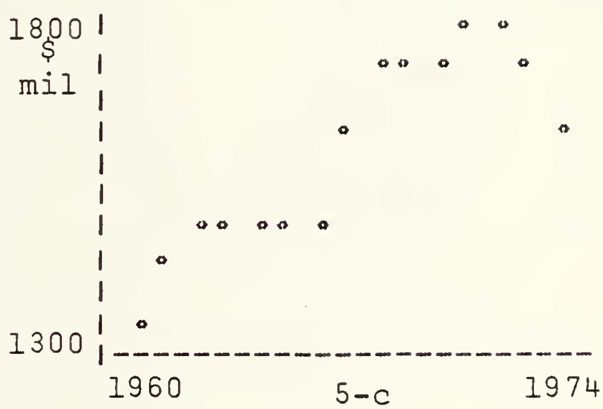
5-a

ACDA



5-b

SIPRI



5-c

SMOOTHED SIPRI

FIGURE 5

CZECHOSLOVAKIAN MILITARY EXPENDITURES
(1960-1974)

TABLE XV

CZECHOSLOVAKIAN SIPRI MX ($CZSMX_t$) RANK ORDER CORRELATIONS

High Range

1.	$POLSMX_t$	.930
2.	$POLSMX_{t-1}$	.928
3.	$GDRSMX_t$	.922
4.	$USSRMX_t$	.887
5.	$NATOT_{t-1}$	.885
6.	$USSRMX_{t-1}$	.864
7.	$GDRSMX_{t-1}$	.851
8.	$HUNSMX_t$	.831

Mid-Range

1.	GNP_t	.785
2.	$HUNSMX_{t-1}$	.788
3.	$NAEUR_t$	.777
4.	$NAEXC_t$	.768
5.	$NAEUR_{t-1}$	.767
6.	$NATOT_t$	.760
7.	$NAEXC_{t-1}$	.758
8.	$TRAEE_t$	.635
9.	$YUGMX_{t-1}$	.631
10.	$TRAUSSR_t$	.629
11.	$TRATOT_t$	.605

Low Range

1.	$FGRMX_{t-1}$	.589
2.	$TRAWEST_t$	.580
3.	$BULSMX_t$	.574
4.	$YUGMX_t$	.571
5.	$FGRMX_t$	.567
6.	$BULSMX_{t-1}$	.534
7.	$BPUSSR_t$	-.409

No Correlation

1.	$BPWEST_t$	-.107
2.	$BPTOT_t$	.008
3.	$BPEE_t$	.006

1972-1974 where SIPRI indicates a sharp spending drop and ACDA a steady increase. Examining the top third of the correlations we find five of the ten variables present in both data sources ($POLSMX_t$, $POLSMX_{t-1}$, $GDRMX_t$, $USSRMX_t$, $GDRSMX_{t-1}$). This tends to place economic factors second to spending decisions made by the USSR, Poland and the GDR. A direct contradiction arises in the case of NATOT (ACDA, low range; SIPRI, high range) while both sources show relatively little correlation with Balance of Payments.

The step-wise regression using smoothed SIPRI data gives the model in Equation 8.

$$CZSMX_t = 890.917 + .379\ POLSMX_t$$

$$r^2 = .8657 \quad (9.155)$$

$$SER = 55.4390$$

$$F = 83.8074$$

$$DW = 1.3144$$

Equation 8

This model has a rather low r^2. This is due to the fact that the sharp decrease in Czech SIPRI spending in 1972-1974 is not supported by the variable set and is thus a questionable occurrence. The ACDA model is more certainly the best of the two.

c. Conclusion

(1) Czechoslovakia defense spending over both data sources is adhering closely to spending policies in the USSR, Poland and the GDR. These variables carry more explanatory effect than do trade and GNP.

(2) Balance of Payments has very low correlations with Czech defense spending.

(3) The ACDA data provides the best forecasting model explaining 99% of the variance while the smoothed SIPRI data explains 87% of the variance in Czech military spending.

3. German Democratic Republic

The GDR is bounded by the FGR to the west, Poland to the east and Czechoslovakia to the south and is occupied by some twenty USSR divisions [2]. There can be no doubt that the presence of 300,000 Soviet ground troops on GDR soil, out of a total WTO complement of 400,000, plays the dominant role when defense spending decisions are made [2]. Thus, we might expect the data to validate the obvious (i.e., the GDR military expenditures are highly correlated with USSR military expenditures).

a. ACDA

Correlations for 31 variables are listed in Appendix E and classified high, mid or low range in Table XVI. As expected, the GDR military expenditures are strongly correlated with those of the USSR followed by Poland, Hungary, NATO Europe and Czechoslovakia. Bulgarian spending is in the mid-range while Rumanian spending is clearly deviating in the low range. It is also significant that trade with the USSR ($TRAUSSR_t$) is in the high range while the remaining trade variables ($TRAEE_t$, $TRATOT_t$ and $TRAWEST_t$) are all in the mid-range. In addition, notice the strong correlation with GNP_t, mid-range correlation with FGR_t and low to no correlations for total NATO spending and Balance of Payments.

TABLE XVI

GDR ACDA MX ($GDRAMX_t$)
RANK ORDER CORRELATIONS

High Range

1.	$USSRMX_t$	.982
2.	$USSRMX_{t-1}$	.977
3.	$POLAMX_t$	.973
4.	$POLAMX_{t-1}$	.972
5.	GNP_t	.955
6.	$HUNAMX_t$	.947
	$NAEUR_t$	.947
7.	$TRAUSSR_t$	.945
8.	$CZAMX_t$	.944
9.	$YUGMX_{t-1}$	.942
10.	$NAEXC_t$	.940
11.	$CZAMX_{t-1}$	.939
	$NAEXC_{t-1}$	.939
12.	$NAEUR_{t-1}$	.934
13.	$HUNAMX_{t-1}$	.907

Mid-Range

1.	$TRAEE_t$	.899
2.	$BULAMX_{t-1}$	.896
3.	$TRATOT_t$	.892
4.	$YUGMX_t$	.889
5.	$BULAMX_t$	.862
6.	$TRAWEST_t$	.842
7.	$FGRMX_t$	.828
8.	$FGRMX_{t-1}$	.811

Low Range

1.	$NATOT_{t-1}$	.742
2.	$BPWEST_t$	.688
3.	$RUMAMX_t$	.622
4.	$NATOT_t$	.585
5.	$RUMAMX_{t-1}$	.540
6.	$BPTOT_t$	-.407

No Correlation

1.	$BPUSSR_t$	.380
2.	$BPEE_t$	.077

When the step-wise regression is performed a satisfactory forecasting model, Equation 9, results.

$$GDRAMX_t = 598.257 + .018\ USSRMX_t + 1.298\ HUNAMX_t$$
$$r^2 = .9825 \quad (7.639) \quad (3.551)$$
$$SER = 93.7183$$
$$F = 337.3311$$
$$DW = 1.966$$

Equation 9

Equation 9 shows $GDRAMX_t$ explained by Soviet and Hungarian military spending. Over 98% of the total variance is explained by the model while all statistics are significant at the .05 level.

b. SIPRI

Correlations for the 31 variables listed in Appendix E are classified in Table XVII.

If the top ten variables from each source are compared we find that eight of ten common to both ACDA and SIPRI ($POLSMX_t$, $POLSMX_{t-1}$, $USSRMX_t$, $USSRMX_{t-1}$, GNP, $HUNSMX_t$, $TRAUSSR_t$, $NAEUR_t$). In addition, higher correlations exist with USSR trade (TRAUSSR) than with the other trade variables. The forecasting model resulting from the step-wise regression is Equation 10.

$$GDRSMX_t = -3011.22 + 1.099\ POLSMX_t + 1.462\ CZSMX_{t-1}$$
$$r^2 = .9671 \quad (5.724) \quad (3.502)$$
$$SER = 122.6196$$
$$F = 176.3187$$
$$DW = 2.58$$

Equation 10

TABLE XVII

GDR SIPRI MX ($GDRSMX_t$) RANK ORDER CORRELATIONS

High Range

1.	$POLSMX_t$	.966
2.	$POLSMX_{t-1}$	.960
3.	$USSRMX_t$	.959
4.	$USSRMX_{t-1}$	.948
5.	$CZSMX_{t-1}$	.937
6.	GNP_t	.913

No Correlation

1.	$BPUSSR_t$	.342
2.	$BPTOT_t$	-.333
3.	$BPEE_t$	-.687

Mid-Range

1.	$NAEUR_{t-1}$	.895
2.	$HUNSMX_t$	.892
	$NAEUR_t$	.892
	$TRAUSSR_t$	.892
	$NAEXC_{t-1}$	.892
3.	$NAEXC_t$	.883
4.	$CZSMX_t$	.871
5.	$HUNSMX_{t-1}$	.837
6.	$TRAEE_t$	.832
7.	$NATOT_{t-1}$	.825
8.	$TRATOT_t$	.819

Low Range

1.	$YUGMX_{t-1}$	.792
2.	$TRAWEST_t$	.76
3.	$FGRMX_t$	.754
4.	$YUGMX_t$	.782
5.	$FGRMX_{t-1}$	.745
6.	$BULSMX_t$	.651
7.	$NATOT_t$	.644
8.	$BULSMX_{t-1}$	.638
9.	$BPWEST_t$	-.567

Equation 10 shows $GDRSMX_t$ explained by current Polish MX and lagged Czech MX. Over 96% of the total variance is explained while all statistics are significant at the .05 level.

c. Conclusion

(1) GDR military expenditures are strongly related to the defense spending of the Soviet Union, Poland and NATO Europe and to the economic variables GNP and USSR trade.

(2) High and mid-range correlations exist with other WTO countries with Bulgaria having the lowest values.

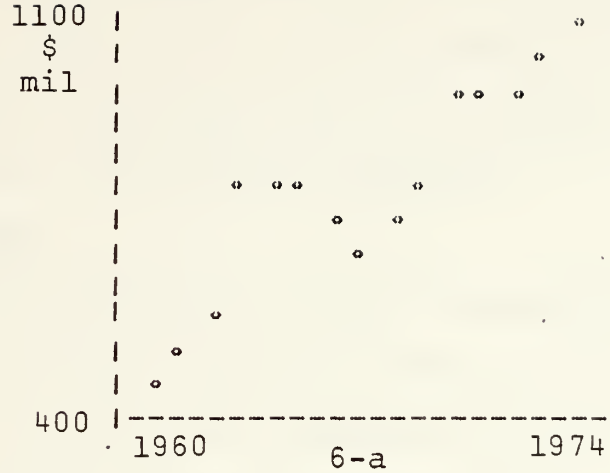
(3) NATO Total Spending and Balance of Payments have low correlations with GDR defense spending.

(4) The ACDA forecasting model explains over 98% of the variance while the SIPRI model explains over 96% of the variance in GDR defense spending.

4. <u>Hungary</u>

Hungary is bounded by Austria, Czechoslovakia, USSR, Rumania and Yugoslavia and is the smallest in area of the WTO countries. The USSR has four divisions permanently stationed in Hungary with the headquarters for the WTO Southern Group at Budapest [2].

The ACDA and SIPRI plots in Figures 6-a and 6-b both show similarities in the Hungarian military spending. In each case spending increases sharply over 1961-1963 and then decreases to 1967 where the upward movement resumes. The only observable difference between the two occurred subsequent to 1969 where



6-a

ACDA

6-b

SIPRI

FIGURE 6

HUNGARIAN MILITARY EXPENDITURES
(1960-1974)

ACDA real spending continued to increase while SIPRI decreased to a constant level in 1972. These similarities in spending suggest some real phenomenon and not a spurious effect so a smoothing of the data was not performed.

a. ACDA

Correlations for the 31 variables listed in Appendix E are classified high, mid or low range in Table XVIII.

It is clear the Hungarian military spending is more closely associated with GDR, NATO European, Polish, Czech and USSR spending decisions than with those of Bulgaria, Rumania and NATO Total Spending. Of the four trade variables only Trade with the USSR ($TRAUSSR_t$) is in the high range, but notice $TRAWEST_t$ ranks ahead of $TRAEE_t$, the first such occurrence in any WTO country. Total NATO Spending and Balance of Payments again rank lowest, but $BPWEST_t$ shows a mild negative correlation not seen in other WTO countries.

The step-wise regression produces the model in Equation 11.

$$HUNAMX_t = 159.271 + .16\ GDRAMX_{t-1} + .067\ FGRMX_t$$

$$r^2 = .9594 \qquad (6.622) \qquad (3.627)$$

$$SER = 35.3428$$

$$F = 141.7026$$

$$DW = 1.805 \qquad\qquad \text{Equation 11}$$

Equation 11 shows Hungarian spending explained by lagged East German spending and current West German spending.

TABLE XVIII

HUNGARIAN ACDA MX ($HUNAMX_t$)
RANK ORDER CORRELATIONS

High Range			Mid-Range			Low Range		
1.	$GDRAMX_{t-1}$	.956	1.	$BULAMX_{t-1}$	.896	1.	$YUGAMX_t$	.786
2.	$GDRAMX_t$	.947	2.	$CZAMX_{t-1}$	.895	2.	$RUMAMX_t$	.700
3.	$NAEUR_t$	.945	3.	$FGRMX_{t-1}$	.885	3.	$RUMAMX_{t-1}$	.679
4.	$NAEXC_t$	.940	4.	$YUGMX_{t-1}$	.881	4.	$NATOT_{t-1}$	.616
5.	$POLAMX_{t-1}$	.934	5.	$TRATOT_t$	.870	5.	$BPWEST_t$	-.408
6.	$POLAMX_t$	.929	6.	$BULAMX_t$	.853	6.	$NATOT_t$	.400
	$NAEUR_{t-1}$	.929	7.	$TRAWEST_t$	.852			
7.	$NAEXC_{t-1}$	.925	8.	$TRAEE_t$	.835		**No Correlation**	
8.	GNP_t	.916				1.	$BPEE_t$	.293
9.	$USSRMX_{t-1}$	.914				2.	$BPUSSR_t$	.227
10.	$CZAMX_t$	.911				3.	$BPTOT_t$	-.034
11.	$USSRMX_t$	.907						
12.	$FGRMX_t$	.906						
13.	$TRAUSSR_t$	.908						

The r^2 of .9594 indicates a very close fit while all summary statistics are significant.

b. SIPRI

Correlations for the 31 variables in Appendix E are classified in Table XVIV.

If the top ten variables in both sources are compared, seven of ten are common to both ($GDRMX_t$, $GDRMX_{t-1}$, $POLMX_t$, $POLMX_{t-1}$, $USSRMX_{t-1}$, $NAEXC_{t-1}$, $NAEUR_{t-1}$). The trade variables are even less significant in the SIPRI than in the ACDA data but still have smaller correlations than GNP.

When the step-wise regression is performed, Equation 12 results.

$$HUNSMX_t = -530.35 + .601\ CZSMX_{t-1}$$
$$r^2 = .8280$$
$$DW = .958$$

Equation 12

Notice the rather low r^2 and serial correlation indicated by a low DW statistic.

Applying the Hildreth-Lu grid search and generalized differencing procedure the final model is obtained in Equation 13.

$$HUNSMX^*_t = -195.0988 + .50\ CZSMX^*_{t-1}$$
$$(4.7303)$$

$r^2 = .6509$

SER = 38.36 where $HUNSMX^*_t = HUNSMX_t - \rho HUNSMX_{t-1}$

F = 22.376 $CZSMX^*_{t-1} = CZSMX_{t-1} - \rho CZSMX_{t-2}$

DW = 1.649 $\rho = .464$

Equation 13

TABLE XVIV

HUNGARIAN SIPRI RANK ORDER CORRELATIONS

High Range			Mid-Range			Low Range		
1.	$CZSMX_{t-1}$	.910	1.	$USSRMX_t$	.766	1.	$YUGMX_{t-1}$	.693
2.	$GDRSMX_t$	.892	2.	$USSRMX_{t-1}$	.763	2.	$FGRMX_t$	.675
3.	$POLSMX_t$	.865	3.	$NAEXC_{t-1}$	.737	3.	$BULSMX_{t-1}$	.668
4.	$GDRSMX_{t-1}$	.845	4.	$NAEUR_{t-1}$	.736	4.	$BULSMX_t$	.660
5.	$NATOT_{t-1}$	.839	5.	$NAEUR_t$	.723	5.	$TRAUSSR_t$	.646
6.	$POLSMX_{t-1}$	.833	6.	GNP_t	.720	6.	$FGRMX_{t-1}$	.645
7.	$CZSMX_t$	.811	7.	$NAEXC_t$	.711	7.	$YUGMX_t$	.604
						8.	$NATOT_t$	.574
						9.	$TRATOT_t$	.569
						10.	$TRAWEST_t$	.550
						11.	$TRAEE_t$	.520

No Correlation		
1.	$BPWEST_t$	-.097
2.	$BPEE_t$	.077
3.	$BPUSSR_t$	.076
4.	$BPTOT_t$	.022

The r^2 = .6509 makes this model of marginal use with only 65% of the variance explained by the independent variable. This indicates that the downturn in 1972 shown in the SIPRI data is not supported by the variable set (excluding Rumanian MX).

c. Conclusion

(1) Hungarian defense spending is strongly related to defense spending by the GDR, Poland, Czechoslovakia, USSR and NATO Europe.

(2) Bulgarian and Rumanian spending has noticeably less correlation than other WTO countries with Hungarian spending.

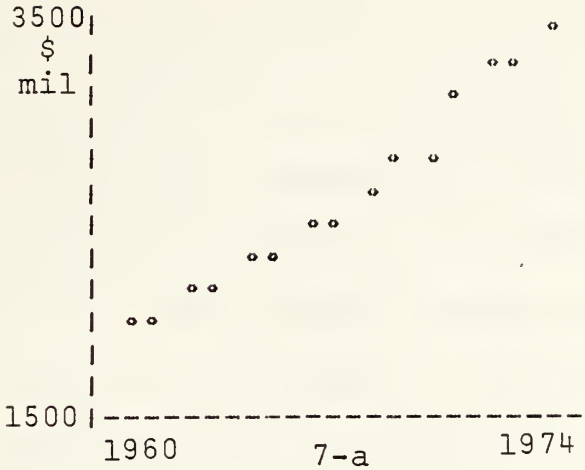
(3) NATO Total Spending and Balance of Payments have little relation to Hungarian spending.

(4) Trade with the USSR has higher correlation with Hungarian spending than the other trade variables.

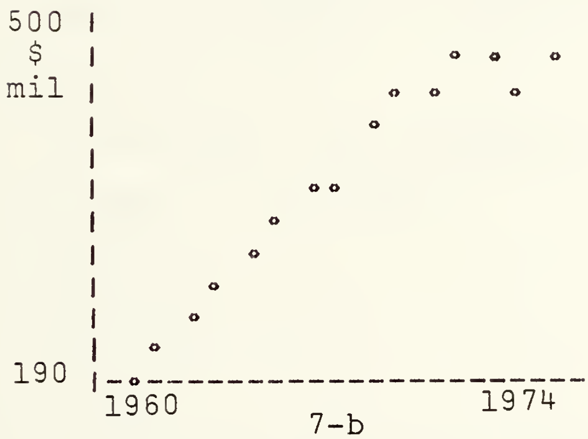
(5) The ACDA forecasting model explains nearly 96% of the total variance in Hungarian spending. The SIPRI model is not very satisfactory, explaining only 65% of the total variance.

5. Poland

Poland is the largest WTO country, surrounded by the GDR, Czechoslovakia and the USSR. The USSR maintains two divisions in Poland with the headquarters for the Northern Group at Leignitz near the Czech and GDR borders [2]. The ACDA and SIPRI data plots of POLMX, Figure 7-a and 7-b, show similar increases



ACDA



SIPRI

FIGURE 7

POLISH MILITARY EXPENDITURES
(1960-1974)

until 1971 where ACDA continues the upward trend while SIPRI levels off.

a. ACDA

Correlations for the 31 variables from Appendix E are classifed in Table XX. Inspection of the high range correlations shows strong association with USSR defense spending and trade, followed by GNP and GDR spending which itself is most highly correlated with $USSRMX_t$. The remaining WTO countries defense spending follows with Bulgaria last in the high range and Rumanian MX quite distant in the low range. NATO European spending and Eastern European trade are also prominent. This is perhaps the classic example of a WTO country closely adhering to the Soviet line.

The step-wise regression produces the forecasting model found in Equation 14.

$$POLAMX_t = 1255.7893 + .0124\ USSRMX_{t-1} + .2391\ POLTRAUSSR_t$$
$$r^2 = .9839 \qquad (3.1207) \qquad (1.9272)$$
$$SER = 69.22$$
$$F = 367.016$$
$$DW = 1.672$$

Equation 14

Equation 14 shows Polish MX explained by lagged Soviet spending and current Polish trade with the USSR. All summary statistics are significant and the $r^2 = .9839$ indicates a very satisfactory model.

b. SIPRI

Correlations for the 31 variables in Appendix E are classified in Table XXI.

TABLE XX

POLISH ACDA MX ($POLAMX_t$) RANK ORDER CORRELATION

High Range

1.	$USSRMX_{t-1}$	.989
2.	$USSRMX_t$	.987
3.	$TRAUSSR_t$	.985
4.	GNP_t	.981
5.	$GDRAMX_{t-1}$	.976
6.	$GDRAMX_t$	.973
7.	$NAEUR_t$	.946
8.	$NAEXC_t$	.940
9.	$CZAMX_t$	.936
10.	$TRAEE_t$	.934
11.	$HUNAMX_t$	.929
12.	$NAEUR_{t-1}$	.928
13.	$HUNAMX_{t-1}$	.926
	$BULAMX_{t-1}$	.926
14.	$NAEXC_{t-1}$	.923
15.	$BULAMX_t$	.921
16.	$CZAMX_{t-1}$	.914
17.	$YUGAMX_{t-1}$	.902

Mid-Range

1.	$TRATOT_t$	.897
2.	$YUGMX_t$	.864
3.	$FGRMX_t$	.811
4.	$TRAWEST_t$	.792
5.	$FGRMX_{t-1}$	.789

No Correlation

1.	$BPEE_t$	-.097

Low Range

1.	$RUMAMX_t$	.700
2.	$NATOT_{t-1}$	.647
3.	$RUMAMX_{t-1}$	.611
4.	$BPWEST_t$	-.602
5.	$BPTOT_t$	-.561
6.	$BPUSSR_t$	.535
7.	$NATOT_t$	.477

TABLE XXI

POLISH SIPRI MX ($POLSMX_t$) RANK ORDER CORRELATIONS

High Range			Mid-Range			Low Range		
1.	$GDRMX_t$	.966	1.	$NAEUR_t$	.893	1.	$FGRMX_{t-1}$	.781
2.	$USSRMX_t$	.955	2.	GNP_t	.887	2.	$TRAEE_t$	.763
3.	$USSRMX_{t-1}$	.944	3.	$TRAUSSR_t$	.886	3.	$FGRMX_t$	.737
	$GDRSMX_{t-1}$	.944	4.	$HUNSMX_{t-1}$	.883	4.	$YUGMX_t$	.723
4.	$NAEUR_{t-1}$	.912	5.	$NAEXC_t$	.882	5.	$TRATOT_t$	.719
5.	$NAEXC_{t-1}$	.908	6.	$CZSMX_{t-1}$	.879	6.	$YUGMX_{t-1}$	.715
			7.	$HUNSMX_t$	.865	7.	$NATOT_t$	.704
No Correlation			8.	$CZSMX_t$	.836	8.	$BULSMX_{t-1}$	.609
1.	$BPWEST_t$	-.352	9.	$NATOT_{t-1}$	.835	9.	$TRAWEST_t$	.575
2.	$BPUSSR_t$	.343				10.	$BULSMX_t$	.567
3.	$BPTOT_t$	-.291						
4.	$BPEE_t$	.009						

When the top ten correlations from both sources are considered, seven of ten ($GDRSMX_t$, $USSRMX_t$, $GDRSMX_{t-1}$, $NAEUR_t$, GNP, TRAUSSR) are common variables. In both data sets trade with the USSR is the most important trade variable. Rumania is once more deviating with a low range ACDA correlation.

The step-wise regression produces the model in Equation 15.

$$
\begin{aligned}
POLSMX_t &= 982.7562 + .4337\ GDRSMX_t + .7111\ HUNSMX_{t-1} \\
r^2 &= .9518 \qquad (6.5553) \qquad\qquad (2.1404) \\
SER &= 84.77 \\
F &= 118.616 \\
DW &= 1.549
\end{aligned}
$$

<u>Equation 15</u>

Equation 15 shows Polish MX explained by current East German and lagged Hungarian spending. Over 95% of the total variance is explained making this a very satisfactory model.

c. Conclusion

(1) Polish defense spending is highly correlated with spending in the GDR, USSR and NATO Europe. Also closely related are Polish trade with the USSR and GNP.

(2) Correlations with Bulgarian spending rank lowest for WTO countries except for Rumanian spending which has the lowest ranking of any country, east or west.

(3) NATO Total Spending and Balance of Payments are not significantly correlated with Polish spending.

(4) The ACDA forecasting model explains 98% of the variance while the SIPRI model explains 95%.

V. SUMMARY

The anlaysis of WTO spending, both region-wide and by respective members shows significant Soviet influence absent in both Bulgaria and Rumania. The remaining countries (Czechoslovakia, GDR, Hungary and Poland) cluster in close agreement with the Soviet Union for most correlations analyzed.

The methodology employed used both ACDA and SIPRI sources so the myriad of military and economic factors could be tested simultaneously in parallel analyses. Such a procedure prevents the peculiarities of the individual sources (ACDA or SIPRI) from forcing a spurious variable into candidacy as a causative factor. Thus, by using the data sources to corroborate each other, more credibility and confidence can be given to the result.

The initial effort of the study tested several hypotheses using non-parametric methods of rank order correlation. The six Eastern European WTO members were aggragated and tested for 1) Trade dependence on the Soviet Union versus conformity in defense policy, 2) Level of economic development versus conformity in defense policy and 3) Susceptibility to USSR military intervention versus conformity in defense policy.

Contrary to the results of Kintner and Klaiber, and in consonance with those of Linden, the author concluded that trade dependence and conformity to Soviet defense policy are

not related. It must be restated that this applies on a region-wide basis and may not be true for individual countries. Certainly in the case of WTO countries in recent years, where increased trade with the West has meant a drop in the percentage trade with the Soviets, no across the board assertion of political or military independence has surfaced. Conversely, Bulgaria, who remains most dependent on Soviet trade is ranked fifth or sixth (next to Rumania) in the two conformity indices constructed.

Both levels of economic development and susceptibility to Soviet military intervention are related to conformity in defense spending. Ease of military intervention shows the strongest correlation with conformity in defense spending. Both results support the conclusions of Linden [10] and Kintner and Klaiber [9]. In the former case, the backward agricultural economies of Bulgaria and Rumania were destined in the Soviet Economic Plan to specialize as suppliers of raw materials and food stuffs for the industrial countries to the north. Rumania rejected this as a guise for exploitation and embarked on a plan for rapid industrial growth. Bulgaria likewise experienced rapid growth in GNP. In the latter case (i.e., ease of military intervention by the Soviets), it is indeed significant that the two most deviant countries in military spending (Bulgaria and Rumania) are the only WTO nations without permanent Soviet troop garrisons. This lends some support to the suggestion that fear of Soviet military intervention, as occurred in Hungary and

Czechoslovakia is a major incentive to staying in line with Kremlin policy (at least in MX).

Certainly one cannot place Bulgaria in the dissident category with Rumania based on the analysis so far. However, Bulgaria presents an interesting case which is worthy of further discussion. Table XXII is a summary of the forecasting models and the top ten correlates common to both data sources. Notice that Bulgaria is the only WTO country which has no other member country's MX among the top third correlates. The emphasis is on trade, GNP and Turkish, Greek and NATO (excluding U.S.) military spending. The USSR, GDR, Czechoslovakia, Hungary, Poland cluster is in the mid-third of the ranked correlations while Rumania is in the bottom third. This result seems significant because the top third correlates for the GDR, Czechoslovakia, Hungary and Poland all contain clusters made up of some or all of the others (CZ with POL, GDR, HUN, USSR; GDR with POL, CZ, HUN, USSR (CZ straddles top-third/mid-third); HUN with GDR, POL (USSR, CZ straddle top-third/mid-third), and POL with GDR, USSR (HUN straddles top-third/mid-third)). Hence, a cluster relationship between Czechoslovakia, GDR, Poland, USSR and Hungary shows Bulgaria noticeably absent. Poland is the example where the complete cluster is not present as Czechoslovakia is missing. The observations can now be made that the "cluster-of-four" (CZ, GDR, HUN, POL) tends to move together with the USSR, even in the case of the Rumanian SIPRI data, which resulted in the rejection of the SIPRI data for Rumania.

TABLE XXII

WTO PREDICTION MODELS AND TOP-TEN CORRELATES

Equation	Model	Top-Ten Correlates
1 3 smoothed	$BULAMX_t = 408.83 + .274\ TRAEE_t$ $+ .519\ TURMX_t$ $BULSMX_t = 7.307 + .023\ FGRMX_t$ $+ .203\ YUGMXt$	$TRAEE_t$ $TURMX_t$ $TURMX_{t-1}$ GNP_t $GREMX_t$ NAEXC $TRAUSSR_t$
7 8 smoothed	$CZAMX^*_t = 663.74 + 104.05\ NAEUR^*_{t-1}$ $CZSMX_t = 890.917 + .379\ POLSMX_t$	$POLMX_t$ $POLMX_{t-1}$ $GDRMX_t$ $GDRMX_{t-1}$ $USSRMX_t$ $HUNMX_t$
9 10	$GDRAMX_t = 598.257 + .018\ USSRMX_t$ $+1.298\ HUNAMX_t$ $GDRSMX_t = -3011.22 + 1.099\ POLSMX_t$ $+1.462\ CZSMX_{t-1}$	$POLMX_t$ $POLMX_{t-1}$ $USSRMX_t$ $USSRMX_{t-1}$ $HUNMX_t$ $\#CZMX_{t-1}$ GNP_t $NAEUR_t$
11 13	$HUNAMX_t = 159.271 + .16\ GDRAMX_{t-1}$ $+ .067\ FGRMX_t$ $HUNSMX^*_t = -195.0988 + .504\ CZSMX_{t-1}$	$GDRMX_t$ $GDRMX_{t-1}$ $POLMX_t$ $POLMX_{t-1}$ $\#USSRMX_{t-1}$ $\#CZMX_t$
14 15	$POLAMX_t = 1255.7893 + .0124\ USSRMX_{t-1}$ $+ .2391\ TRAUSSR_t$ $POLSMX_t = 982.7562 + .4337\ GDRSMX_t$ $+ .711\ HUNSMX_{t-1}$	$GDRMX_t$ $GDRMX_{t-1}$ $USSRMX_t$ $USSRMX_{t-1}$ $\#HUNMX_{t-1}$ $NAEXC_t$ $NAEUR_t$ GNP_t $TRAUSSR_t$
4 smoothed	$RUMAMX_t = 1057.417 + .762\ TRAEE_t$ $- .179\ TRAWEST_t$ REJECT SIPRI	$BULMX_t$ $BULMX_{t-1}$ $TRATOT_t$ $TRAEE_t$ $TRAUSSR_t$ GNP_t $TRAWEST_t$ $POLMX_t$ $POLMX_{t-1}$

\# Indicates straddles Top-third/mid-third

GNP is a significant top-ten correlate in four of the six countries (BUL, GDR, POL, RUM) while NATO ($NAEXC_t$ or $NAEUR_t$) variables are present in three of the six countries (BUL, GDR, POL). So while the GDR and POL seem in step with the USSR there is also close attention paid to domestic economic changes as well as Western Europe military spending.

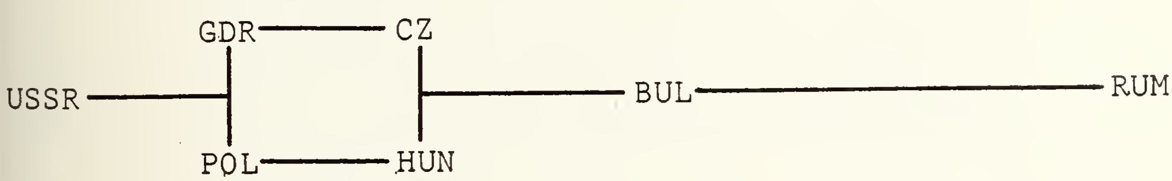
Thus, we conclude that Czechoslovakia, GDR, Hungary and Poland are all significantly acting according to the desires of the USSR in regards to defense policy. Bulgaria, while independent to some degree, cannot be placed in the same class with Rumania regarding Soviet defense policy. This is clearly shown in the correlation with $USSRMX_t$ computed for data sources for both countries. Bulgaria had correlation coefficients of $\rho_{ACDA} = .875$ and $\rho_{SIPRI} = .618$ while Rumania had $\rho_{ACDA} = .599$. This puts Bulgaria just outside the "cluster-of-four" but not in any close association with Rumania.

The Rumanian case shows top-third correlates with Bulgarian, Polish and Yugoslavian MX. Also prominent are the four trade variables and GNP. It should be noted that these correlates have much lower values than seen in the other countries. Thus, Polish MX, with a correlation coefficient of .825, does not produce the strong association of Bulgarian MX or Trade with Eastern Europe. The notable observation in the case of Rumania is the fluctuations in military expenditures. That $TRAEE_t$, $TRAUSSR_t$ and $TRATOT_t$ are among the top-five correlates indicates the underlying influence of these economic factors.

Appendix F discusses the stress placed on Rumanian economic development and the need to openly trade with the West for high technology and equipment. This of course caused a reduction in trade with WTO nations. Such total-share decreases are reflected in the close association with $RUMAMX_t$ of the $TRAEE_t$ and $TRAUSSR_t$ variables. Also interesting is the forecasting model for Rumania in Table XXII. Notice the model shows some trade off between $TRAEE_t$ and $TRAWEST_t$, indicating that more trade with the West goes together with lower military spending.

The basic relationship might be expressed as shown below. The USSR is depicted as the defense policy most desired by the Kremlin. Conformity is measured from left to right shows Poland and the GDR leading the cluster which also includes Czechoslovakia and Hungary. Bulgaria does not hold a dissident position but occupies a stance distinctly to the right of the cluster countries. Rumania is clearly an outlier sitting alone as the sole deviant.

CONFORMITY



Finally, we conclude that Czechoslovakia, the GDR, Hungary and Poland are the loyal supporters of USSR defense policy while Bulgaria seeks a moderately independent course and Rumania a dissident one. The analysis has shown both economic and

military factors underly the degree of conformity to the dictates of the Kremlin. In the case of economic factors, Bulgaria and Rumania have the lowest GNP-per-capita and the largest rate of growth over the time period studied. The other four countries, while more industrialized, had lower GNP growth rates over the same time period. The strongest influence observed is fear of military intervention. The countries having permanent garrisons of Soviet troops cluster together in the correlation analysis while those without Soviet troops are in noticeable disunion with the Pact leader.

Lastly, some measure of agreement was found (except in the case of Rumania) between the ACDA and SIPRI data sources. This was not an expected result given the hesitancy of the author in accepting official data published by the WTO nations. There is no doubt that further study is needed in the area of direct costing estimation and currency conversion methods. Such improvements in the data base will hopefully lead to increased confidence in the conclusions.

APPENDIX A

LIST OF ACRONYMS AND ABBREVIATIONS*

ACDA	-	Arms Control and Disarmament Agency
ACI	-	ACDA Conformity Index
AMX	-	ACDA Military Expenditures
BE	-	Budget Estimate
BP	-	Balance of Payments
BUL	-	Bulgaria
CER	-	Cost Estimating Relationship
CIA	-	Central Intelligence Agency
COMECON	-	Council for Mutual Economic Assistance
CMEA	-	Council for Mutual Economic Aid
CZ	-	Czechoslovakia
EDI	-	Economic Development Index
EE	-	Eastern Europe
EUR	-	Western Europe
EXC	-	Excludes U.S.
FGR	-	Federal German Republic (West Germany)
GDR	-	German Democratic Republic (East Germany)
GNP	-	Gross National Product
GRE	-	Greece
HUN	-	Hungary
ISS	-	Institute for Strategic Studies
MC	-	Military Construction
MII	-	Military Intervention Index

MX	-	Military Expenditures
NA	-	NATO Military Expenditures
NMP	-	Net Material Product
NMILT	-	Number of Military Peronnel
NSE	-	National Security Expenditures
O & M	-	Operations and Maintenance
PC	-	Procurement
POL	-	Poland
POP	-	Population
PPM	-	Personnel Pay and Maintenance
RDT & E	-	Research, Development, Testing and Evaluation
RUM	-	Rumania
RWP	-	Rumanian Workers Party
SCI	-	SIPRI Conformity Index
SIPRI	-	Stockholm International Peace Research Institute
SMX	-	SIPRI MX
SRI	-	Stanford Research Institute
TCI	-	Trade Conformity Index
TOT	-	Total
TRA	-	Trade
TUR	-	Turkey
USSR	-	Union of Soviet Socialist Republics
WEST	-	Western Countries
WTO	-	Warsaw Treaty Organization
YUG	-	Yugoslavia

*Note: Abbreviations may be concatenated to further describe a variable (e.g., BULSMX - Bulgarian SIPRI Military Expenditures; NAEUR - NATO Military Expenditures for Western Europe).

APPENDIX B-1

DATA SOURCES

	Variable	Years	Sources
1.	NATO and WTO Military Expenditures (NATOT, NAEXC, NAEUR, WTOMX, SIPRI variables).	1959-1974	World Armaments and Disarmaments SIPRI Yearbook 1975.
2.	GNP (All countries).	1960-1974	CIA Handbook of Economic Statistics 1975, 1977.
3.	Population (POP_t, all countries).	1960-1974	UN Demographic Yearbook.
4.	Number of Military Personnel (NMILT) and MX (all countries).	1964-1974	The Military Balance by Institute for Strategic Studies.
5.	Trade (TRATOT, TRAUSSR, TRAEE, TRAWEST, BPUSSR, BPEE, BPWEST, for all WTO countries).	1960-1974	Soviet and East European Foreign Trade, 1946-1969 by Paul Marer and Yearbook of International Trade Statistics.
6.	WTO ACDA Military Expenditures.	1960-1974	World Military Expenditures and Arms Transfers 1965-1974 and Military Expenditures in Eastern Europe: Some Alternative Estimates by Thad P. Alton.
7.	Soviet Union Military Expenditures (USSRMX).		The Estimation of Soviet Defense Expenditures, 1955-1975 by W.T. Lee.

	Variable	Years	Source
8.	GNP Implicit Price Deflators.	1960-1974	World Tables 1976, International Bank for Reconstruction and Development.
9.	Area	1966,1974	World Almanac, 1977.

APPENDIX B-2

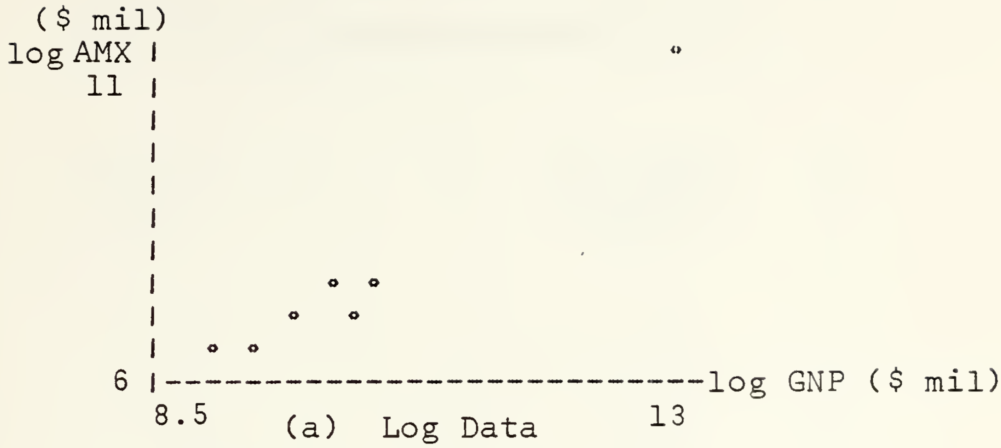
CROSS-SECTIONAL DATA 1966, 1974

1966

	MX($mil)		GNP	POP	AREA	NMILT	
	ACDA	SIPRI	($mil)	(mil)	(sq mi)	(thous)	
BUL	718	207	7530	8.26	42,829	156	BUL
CZ	1710	1275	23800	14.2	49,371	220	CZ
GDR	1360	944	28200	17.1	40,646	122	GDR
HUN	672	301	11700	10.2	35,919	109	HUN
POL	2070	1584	33400	31.5	120,359	260	POL
RUM	1120	546	16600	19.1	91,699	201	RUM
USSR	55300	47000	364000	234	8647,250	3165	USSR

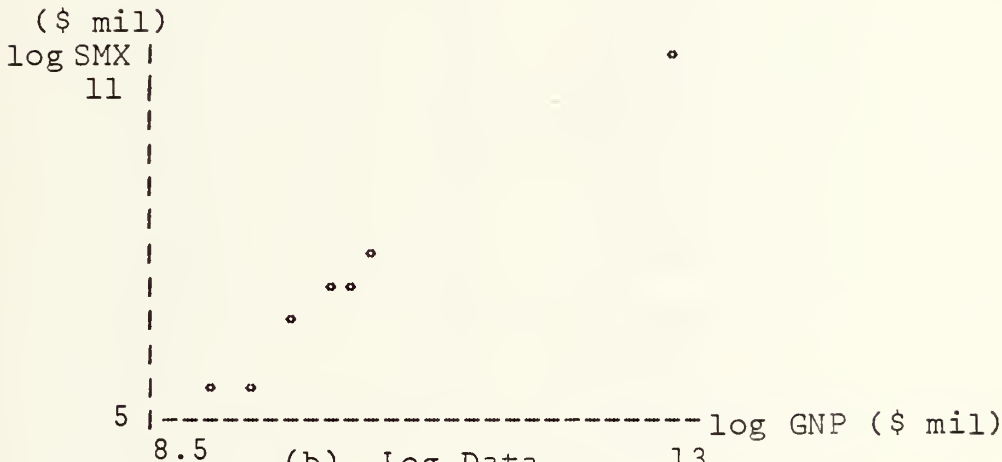
1974

	MX($mil)		GNP	POP	AREA	NMILT	
	ACDA	SIPRI	($mil)	(mil)	(sq mi)	(thous)	
BUL	1560	416	19400	8.68	42,829	152	BUL
CZ	3070	2035	48100	14.7	49,371	200	CZ
GDR	3470	2625	59900	16.9	40,646	145	GDR
HUN	1360	611	23500	10.5	35,919	103	HUN
POL	4300	2839	76200	33.7	120,359	303	POL
RUM	1980	910	43300	21.0	91,699	171	RUM
USSR	103000	61900	797000	252	8647,250	3525	USSR



(a) Log Data

Log GNP vs log ACDA MX



(b) Log Data

Log GNP vs log SIPRI MX

APPENDIX B-3

1966 LOG DATA PLOTS

APPENDIX B-4

GNP IMPLICIT PRICE DEFLATORS [18]

	Deflator D_i	1970 Index D_b/D_i
1959	.950	1.326
1960	.963	1.308
1961	.975	1.292
1962	.987	1.277
1963	1.00	1.26
1964	1.017	1.239
1965	1.036	1.216
1966	1.065	1.183
1967	1.098	1.148
1968	1.138	1.107
1969	1.194	1.055
1970	1.26	1.00
1971	1.319	.955
1972	1.362	.925
1973	1.432	.880
1974	1.574	.801

NOTE: Conversion to any constant base year is calculated as follows:

$$C_{bi} = \frac{D_b}{D_i}$$

D_i=Deflator for year
D_b=Deflator for base year desired
C_{bi}=Constant index for base year b in year i

Equation: $C_{70,74} = \frac{D_{70}}{D_{74}} = \frac{1.26}{1.574} = .801$

APPENDIX B-4

ACDA MILITARY EXPENDITURES [6]
($ mil current)

	BUL	CZ	GDR	HUN	POL	RUM
1959	500	1050	565	405	1330	930
1960	565	1192	586	424	1468	1015
1961	604	1247	593	447	1591	1055
1962	645	1375	1033	528	1655	1090
1963	632	1442	1158	665	1781	1127
1964	680	1615	1191	676	1895	1141
1965	695	1680	1300	696	1980	1120
1966	718	1710	1360	672	2070	1120
1967	744	1850	1500	673	2200	1070
1968	769	1940	1930	745	2460	1140
1969	829	2020	2120	829	2700	1320
1970	930	2050	2370	989	2910	1470
1971	1030	2340	2540	1060	3280	1480
1972	1150	2470	2750	1100	3630	1720
1973	1310	2740	3110	1180	3860	1830
1974	1560	3070	3470	1360	4300	1980

APPENDIX B-4

ACDA MILITARY EXPENDITURES
($ mil constant 1970)

	BUL	CZ	GDR	HUN	POL	RUM
1959	663	1393	749	537	1764	1300
1960	739	1560	767	555	1921	1328
1961	781	1612	766	578	2056	1363
1962	823	1755	1319	674	2113	1392
1963	796	1817	1459	838	2244	1420
1964	843	2001	1476	838	2348	1414
1965	845	2043	1581	846	2408	1362
1966	850	2023	1609	795	2449	1325
1967	854	2123	1721	772	2525	1228
1968	851	2148	2137	825	2724	1262
1969	875	2132	2237	870	2849	1393
1970	930	2050	2370	989	2910	1470
1971	984	2235	2426	1013	3133	1414
1972	1064	2285	2544	1018	3358	1591
1973	1153	2411	2736	1038	3396	1610
1974	1249	2458	2778	1089	3442	1585

APPENDIX B-4

SIPRI MILITARY EXPENDITURES [17]
($ mil current)

	BUL	CZ	GDR	HUN	POL	RUM
1959	141	1035	396	144	898	365
1960	154	1033	295	179	937	360
1961	187	1119	295	194	1069	386
1962	222	1276	796	283	1154	416
1963	256	1274	826	374	1300	439
1964	224	1202	855	355	1374	461
1965	198	1191	914	332	1461	502
1966	207	1275	944	301	1584	546
1967	213	1457	1062	313	1661	610
1968	228	1560	1711	440	1905	670
1969	260	1679	1858	567	2105	749
1970	279	1755	2006	570	2244	768
1971	305	1876	2124	570	2367	787
1972	337	2012	2242	543	2481	818
1973	364	1976	2457	567	2463	840
1974	416	2035	2625	611	2839	910

APPENDIX B-4

SIPRI MILITARY EXPENDITURES
($ mil constant 1970)

	BUL	CZ	GDR	HUN	POL	RUM
1959	187	1373	525	191	1191	484
1960	202	1352	386	234	1226	471
1961	242	1446	381	251	1381	499
1962	283	1629	1016	361	1473	531
1963	323	1605	1041	471	1638	553
1964	278	1489	1059	440	1702	571
1965	241	1449	1112	404	1777	611
1966	245	1508	1117	356	1874	646
1967	244	1672	1219	359	1906	700
1968	252	1727	1894	487	2109	742
1969	274	1772	1961	598	2221	790
1970	279	1755	2006	570	2244	768
1971	291	1792	2029	545	2261	752
1972	312	1861	2074	502	2295	757
1973	320	1739	2162	499	2167	739
1974	333	1629	2101	489	2273	729

APPENDIX B-4

MILITARY EXPENDITURES USSR
(Lee Estimates .5 ruble/$) [4]

	(Current $ bil)	(Constant 1970 $ bil)
1959	27	35.8
1960	29.8	39.0
1961	32.2	41.6
1962	36.8	47.0
1963	41.8	52.7
1964	46.2	57.2
1965	48.6	59.1
1966	58.4	69.1
1967	66.0	75.7
1968	77.0	85.3
1969	84.4	89.1
1970	91.8	91.8
1971	103.2	98.6
1972	112.4	104.0
1973	127.0	111.8
1974	138.2	110.6

APPENDIX B-4

NON-WTO MILITARY EXPENDITURES [17]
($ mil constant 1970)

	FGR	TUR	GRE	YUG
1959	4047	381	197	540
1960	4375	401	209	514
1961	4612	434	202	571
1962	5854	450	206	564
1963	6580	463	211	568
1964	6306	501	219	588
1965	6232	532	237	569
1966	6041	517	257	544
1967	6283	521	331	540
1968	5578	551	387	612
1969	6117	541	438	618
1970	6188	579	474	629
1971	6625	677	501	619
1972	7086	703	534	695
1973	7363	738	533	634
1974	7757	816	510	783

APPENDIX B-4

NUMBER OF MILITARY PERSONNEL [7]
$NMILT_t$ (thous)

	BUL	CZ	GDR	HUN	POL	RUM	USSR
1964	150	235	106	104	272	222	3300
1965	152	235	112	109	277	198	3150
1966	156	220	122	109	260	201	3165
1967	154	225	127	102	270	173	3220
1968	153	225	126	102	274	173	3280
1969	154	230	137	97	275	193	3300
1970	149	168	129	101	242	181	3308
1971	148	185	126	103	265	160	3375
1972	146	185	131	103	274	174	3375
1973	152	190	132	103	280	170	3425
1974	152	200	145	103	303	171	3525

APPENDIX B-4

NATO MILITARY EXPENDITURES
($ bil constant 1970)

	NATOT	NAEXC	NAEUR
1959	82.116	20.924	18.771
1960	81.314	21.76	19.617
1961	84.545	22.537	20.335
1962	91.817	24.576	22.282
1963	91.699	25.419	23.285
1964	89.954	25.858	23.637
1965	89.523	25.775	23.792
1966	101.973	25.93	23.895
1967	114.793	27.063	24.878
1968	116.407	26.304	24.244
1969	112.547	26.273	24.331
1970	104.564	26.71	24.67
1971	99.821	28.045	25.995
1972	101.461	29.373	27.318
1973	98.286	29.691	27.639
1974	96.468	30.117	27.985

APPENDIX B-4

BULGARIAN TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1959	1046.5	275.1	545.8	151.2
1960	1204.1	325.5	639.6	158.2
1961	1328.6	374.5	692.4	165.6
1962	1557.3	390.0	830.8	206.2
1963	1767.2	455.6	946.1	246.6
1964	2042.1	436.4	1082.2	359.3
1965	2353.6	510.7	1202.2	448.4
1966	2783.3	525.5	1370.1	646.5
1967	3030.1	628.2	1555.0	585.1
1968	3397.4	668.8	1840.0	530.0
1969	3543.7	747.6	1953.4	477.4
1970	3834.8	814.4	2033.3	614.3
1971	4302.0	918.5	2304.4	574.9
1972	5193.7	1174.3	2819.0	644.4
1973	6568.0	1467.7	3500.4	874.9
1974	8161.4	1764.7	3817.1	1257.5

APPENDIX B-4

BULGARIAN TRADE
($ mil constant 1970)

	TOT	EE	USSR	WEST
1960	1575.5	837.0	425.9	207.0
1961	1717.0	895.0	484.0	214.0
1962	1988.0	1061.0	497.9	263.0
1963	2226.7	1192.0	574.1	310.7
1964	2530.0	1341.0	540.7	445.2
1965	2862.5	1462.0	621.1	545.4
1966	3292.9	1621.0	621.7	764.9
1967	4377.2	1784.0	720.9	671.4
1968	3761.6	2037.0	740.5	586.8
1969	3739.6	2061.0	788.9	503.8
1970	3834.8	2033.0	814.4	614.0
1971	4109.6	2201.0	877.4	549.2
1972	4804.7	2608.0	1086.0	596.1
1973	5779.1	3080.0	1291.4	769.8
1974	6533.3	3056.0	1412.7	1006.6

APPENDIX B-4

BULGARIAN TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	53.12	27.03	13.14
1961	52.12	28.19	12.46
1962	53.35	25.04	13.24
1963	53.54	25.78	13.95
1964	52.99	21.37	17.59
1965	51.08	21.70	19.05
1966	49.23	18.88	23.23
1967	51.32	20.73	19.31
1968	54.16	19.69	15.59
1969	55.12	21.11	13.48
1970	53.02	21.24	16.0
1971	53.57	21.35	13.37
1972	54.28	22.61	12.41
1973	53.29	22.35	13.32
1974	46.77	21.62	15.41
MEAN	52.464	22.58	15.45

APPENDIX B-4

RUMANIAN TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1960	1365	362	547	304.6
1961	1607	379	650	421.2
1962	1759	428	714	464.1
1963	1937	433	812	495.3
1964	2168	485.8	915	520
1965	2179	470	845	545
1966	2399	494	804	692
1967	2942	549	829	1092
1968	3077	621	882	1066
1969	3374	726	918	1157
1970	3811	843	1030	1304
1971	4204	926	1051	1458
1972	5234	1134	1284	1838
1973	7166	1552	1507	3206
1974	10018	1831	1578	4183
1975	10679	2039	1983	3696

APPENDIX B-4

RUMANIAN TRADE
($ mil constant 1970)

	TOT	USSR	EE	WEST
1960	1786.0	715.7	473.6	398.5
1961	2076.7	840.0	489.8	544.3
1962	2245.5	911.5	546.4	592.5
1963	2440.6	1023.1	545.6	623.7
1964	2686.0	1133.6	601.9	644.2
1965	2650.1	1027.7	571.6	662.8
1966	2838.3	951.2	584.5	818.7
1967	3376.1	951.3	630.0	1253.1
1968	3406.9	976.6	687.6	1180.3
1969	3559.4	968.7	766.1	1221.0
1970	3811.0	1030.0	843.0	1304.0
1971	4016.0	1004.0	884.6	1392.8
1972	4842.0	1187.8	1049.1	1700.4
1973	6305.3	1325.0	1365.6	2820.9
1974	8019.5	1263.2	1465.7	3348.5

APPENDIX B-4

BULGARIAN TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	40.07	26.52	22.32
1961	40.45	23.58	26.21
1962	40.59	24.33	26.38
1963	41.92	22.35	25.57
1964	42.2	22.4	23.98
1965	38.78	21.57	25.01
1966	33.51	20.59	28.85
1967	28.18	18.66	37.11
1968	28.68	20.19	34.63
1969	27.26	21.53	34.29
1970	27.03	22.11	34.2
1971	25.01	22.04	34.69
1972	24.52	21.66	35.11
1973	21.03	21.66	44.74
1974	15.75	18.28	41.76
MEAN	31.66	21.83	31.66

APPENDIX B-4

CZECH TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1960	3745	1085	1289	630
1961	4070	1242	1369	733
1962	4264	1347	1610	660
1963	4622	1383	1799	707
1964	5005	1514	1875	845
1965	5361	1640	1977.7	909
1966	5481	1643	1835	1034
1967	5545	1723	1943	1031
1968	6083	1960	2044	1165
1969	6618	2063	2230	1251
1970	7486	2368	2430	1595
1971	8190	2558	2682	1550
1972	9578	3114	3217	1946
1973	12173	4057	3752	2691
1974	14586	4606	4153	3467

APPENDIX B-4

CZECH TRADE
($ mil constant 1970)

	TOT	USSR	EE	WEST
1960	4900	1686.5	1419.6	824.3
1961	5259.7	1769.2	1605	947.3
1962	5443.4	2055.3	1719.6	842.6
1963	5823.7	2266.7	1742.6	890.8
1964	6200.9	2323	1875.8	1046.9
1965	6520.1	2405.7	1994.6	1105.5
1966	6484.6	2171	1943.8	1223.3
1967	6363.1	2229.7	1977.2	1183.1
1968	6735.1	2263.1	2170.1	1289.9
1969	6983.8	2353.3	2177	1320.2
1970	7486	2430	2368	1595
1971	7823.7	2562	2443.6	1480.7
1972	8860.7	2976.1	2880.8	1800.3
1973	10710.9	3301.3	3569.7	2367.8
1974	11676.2	3324.5	3687.1	2775.4

APPENDIX B-4

CZECH TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	34.42	28.97	16.82
1961	33.64	30.52	18.01
1962	37.76	31.59	15.48
1963	38.92	29.92	15.3
1964	37.46	30.25	16.88
1965	36.89	30.59	16.96
1966	33.48	29.98	18.87
1967	35.04	31.07	18.59
1968	33.6	32.22	19.15
1969	33.69	31.18	18.9
1970	32.46	32.63	21.3
1971	32.75	31.23	18.93
1972	33.58	32.51	20.31
1973	30.82	33.33	22.1
1974	28.47	31.58	23.76
MEAN	34.2	31.17	18.76

APPENDIX B-4

GDR TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1960	4402	1084	1883	778
1961	4532	1210	1983	767
1962	4786	1233	2339	698
1963	5044	1292	2449	764
1964	5565	1412	2595	924
1965	5880	1546	2516	1068
1966	6420	1696	2661	1199
1967	6735	1821	2826	1206
1968	7184	2066	3060	1241
1969	8277	2261	3402	1541
1970	9428	2644	3687	1929
1971	10058	2912	3837	2089
1972	12088	3560	4554	2630
1973	15374	4703	5324	3359
1974	18394	5243	5777	4701

APPENDIX B-4

GDR TRADE
($ mil constant 1970)

	TOT	USSR	EE	WEST
1960	5759.6	2463.7	1418.3	1017.9
1961	5856.7	2562.6	1563.7	991.2
1962	6109.8	2986	1574	891.1
1963	6355.4	3085.7	1627.9	962.6
1964	6894.7	3215	1749.4	1144.8
1965	7151.4	3060	1880.3	1298.9
1966	7595.5	3148.2	2006.5	1418.5
1967	7728.7	3243	2089.7	1383.9
1968	7954.2	3388	2287.5	1374
1969	8734.5	3590.1	2386	1626.2
1970	9428	3687	2644	1929
1971	9608.1	3665.4	2781.7	1995.6
1972	11182.7	4213	3293.4	2433
1973	13527.4	4684.5	4138.1	2955.5
1974	14724.5	4624.5	4197.1	3763.2

APPENDIX B-4

GDR TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	42.78	24.63	17.67
1961	43.76	26.7	16.92
1962	48.87	25.76	14.58
1963	48.55	25.61	15.15
1964	46.63	25.37	16.60
1965	42.79	26.29	18.16
1966	41.45	26.42	18.68
1967	41.96	27.04	17.91
1968	42.59	28.75	17.27
1969	41.1	27.32	18.62
1970	39.1	28.04	20.46
1971	38.15	28.95	20.77
1972	37.67	29.45	21.76
1973	34.63	30.59	21.85
1974	31.4	28.5	26.09
MEAN	41.43	27.29	18.83

APPENDIX B-4

HUNGARIAN TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1960	1850	595	559	417
1961	2054	654	688	441
1962	2248	729	809	439
1963	2511	782	860	549
1964	2846	862	988	652
1965	3030	883	1079	692
1966	3159	831	1044	781
1967	3476	1024	1205	843
1968	3592	1064	1331	805
1969	4012	1135	1439	995
1970	4823	1336	1639	1323
1971	5490	1422	1893	1319
1972	6446	1864	2281	1579
1973	8445	2416	2843	2219
1974	10704	3014	3225	3016

APPENDIX B-4

HUNGARIAN TRADE
($ mil constant 1970)

	TOT	USSR	EE	WEST
1960	2420.6	731.4	778.5	545.6
1961	2654.4	889.1	845.2	569.9
1962	2869.8	1032.8	930.6	560.4
1963	3163.9	1083.6	985.3	691.7
1964	3526	1224.1	1068	807.8
1965	3685.1	1312.3	1073.9	841.6
1966	3737.4	1235.2	1101.5	924
1967	3988.9	1382.8	1175.1	967.4
1968	3977.1	1473.7	1178.1	891.3
1969	4233.8	1518.5	1197.7	1050
1970	4823	1639	1336	1323
1971	5244.4	1808.3	1358.4	1260
1972	5963.3	2110.2	1724.4	1460.7
1973	7430.7	2501.5	2125.8	1952.5
1974	8568.6	2581.6	2412.7	2414.3

APPENDIX B-4

HUNGARIAN TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	30.22	32.16	22.54
1961	33.50	31.84	21.47
1962	35.99	32.43	19.53
1963	34.25	31.14	21.86
1964	34.72	30.29	22.91
1965	35.61	29.14	22.84
1966	33.05	29.47	24.72
1967	34.67	29.46	24.25
1968	37.06	29.62	22.4
1969	35.86	28.29	24.8
1970	33.98	27.7	27.44
1971	34.49	25.9	24.02
1972	35.59	28.92	24.5
1973	33.6	28.61	26.27
1974	30.13	28.61	28.17
MEAN	34.168	29.542	23.848

APPENDIX B-4

POLISH TRADE [19,20]
($ mil current)

	TOT	EE	USSR	WEST
1960	2821	735.4	856	779
1961	3190	835	975	925
1962	3532	960	1147	946
1963	3749	1008	1205	967
1964	4169	1098	1364	1098
1965	4568	1234	1510	1126
1966	4766	1223	1533	1302
1967	5171	1316	1823	1376
1968	5711	1447	2053	1503
1969	6351	1632	2322	1597
1970	7155	1898	2612	1789
1971	7910	2073	2813	2095
1972	10257	2666	3407	2994
1973	14142	3562	3961	5205
1974	18809	4077	4726	7720

APPENDIX B-4

POLISH TRADE
($ mil constant 1970)

	TOT	USSR	EE	WEST
1960	3691	1120	961.7	1019.3
1961	4122.5	1260	1079.1	1195.4
1962	4508.9	1464.3	1225.5	1207.7
1963	4723.7	1593.9	1270.1	1218.4
1964	5165.4	1689.9	1360.4	1360.4
1965	5555.7	1836.5	1500.8	1369.5
1966	5638.6	1813.7	1446.9	1540.4
1967	5933.9	2092	1510.2	1579
1968	6323.3	2273.1	1602.1	1664.1
1969	6702.1	2450.4	1722.2	1685.3
1970	7155	2612	1898	1789
1971	7556.2	2687.2	1980.3	2001.3
1972	9488.9	3151.9	2466.3	2769.8
1973	12443.4	3485.2	3134.2	4579.8
1974	15056.8	3783.2	3263.7	6179.9

APPENDIX B-4

POLISH TRADE PERCENTAGE (%)

	USSR	EE	WEST
1960	30.34	26.07	27.61
1961	30.56	26.17	29.0
1962	32.47	27.18	26.78
1963	33.74	26.89	25.79
1964	32.72	26.84	26.34
1965	33.06	27.01	24.65
1966	32.17	25.66	27.32
1967	35.25	25.45	26.61
1968	35.95	25.34	26.31
1969	36.55	25.7	25.14
1970	36.51	26.52	25.01
1971	35.56	26.2	26.49
1972	33.22	25.99	29.19
1973	28.01	25.19	36.8
1974	25.13	21.68	41.05
MEAN	32.75	25.83	28.27

APPENDIX B-4

GROSS NATIONAL PRODUCT [21]
($ mil current)

	BUL	CZ	GDR	HUN	POL	RUM	USSR
1960	4563	19345	21531	8406	22399	10890	
1961	4849	20114	21683	8830	24190	11628	
1962	5259	20384	22274	9199	23868	12031	
1963	5500	20000	23000	9700	25300	12900	277000
1964	6100	21200	24000	10500	26900	14000	305000
1965	6750	22000	26500	10900	30700	14800	333000
1966	7530	23800	28200	11700	33400	16600	364000
1967	8230	25600	30400	12700	35700	18100	399000
1968	9200	27400	32900	13600	38700	19900	440000
1969	10400	29700	36500	14500	42000	22000	475000
1970	11600	32600	39800	15900	46200	24500	537000
1971	13100	35400	43100	17100	50800	28000	585000
1972	14600	37900	46600	18300	56400	31400	621000
1973	16700	41900	51800	20400	64500	36100	698000
1974	19400	48100	59900	23500	76200	43300	797000

APPENDIX B-4

GROSS NATIONAL PRODUCT
($ mil constant 1970)

	BUL	CZ	GDR	HUN	POL	RUM
1960	5970	25311	28171	10999	29307	14249
1961	6266	25993	28021	11411	31261	15027
1962	6714	26022	28435	11743	30470	15359
1963	6930	25200	28980	12222	31878	16254
1964	7558	26265	29735	13009	33327	17345
1965	8210	26757	32230	13257	37338	18000
1966	8909	28158	33363	13842	39515	19639
1967	9444	29377	34885	14574	40967	20770
1968	10186	30337	36427	15058	42849	22033
1969	10975	31342	38518	15302	44322	23216
1970	11600	32600	39800	15900	46200	24500
1971	12514	33817	41172	16335	48528	26748
1972	13507	35062	43110	16930	52176	29048
1973	15449	36867	45578	17950	56753	31764
1974	15530	38504	47950	18812	60999	34662

APPENDIX B-4

GNP PER-CAPITA
($ constant 1970)

1960	759	1854	1750	1102	987	774
1961	789	1836	1751	1141	1046	808
1962	838	1877	1766	1163	1006	821
1963	858	1807	1778	1210	1042	865
1964	928	1876	1791	1288	1079	918
1965	1001	1898	1919	1301	1197	947
1966	1079	1983	1951	1357	1254	1028
1967	1137	2054	2040	1429	1292	1076
1968	1217	2122	2130	1462	1339	1118
1969	1300	2192	2253	1486	1377	1160
1970	1366	2280	2328	1544	1422	1207
1971	1465	2348	2408	1571	1480	1305
1972	1574	2418	2536	1628	1576	1403
1973	1792	2525	2681	1726	1699	1527
1974	1789	2619	2837	1792	1810	1651
	1192.8	2112.6	2127.9	1413.3	1307.1	1107.2
	5	2	1	3	4	6

APPENDIX B-4

POPULATION [22]
(millions)

	BUL	CZ	GDR	HUN	POL	RUM	USSR
1960	7.867	13.65	16.1	9.98	29.7	18.4	214
1961	7.943	13.78	16.0	10.0	29.9	18.6	218
1962	8.013	13.86	16.1	10.1	30.3	18.7	221
1963	8.078	13.95	16.3	10.1	30.6	18.8	225
1964	8.144	14.0	16.6	10.1	30.9	18.9	228
1965	8.2	14.1	16.8	10.2	31.2	19.0	231
1966	8.26	14.2	17.1	10.2	31.5	19.1	234
1967	8.31	14.3	17.1	10.2	31.7	19.3	236
1968	8.37	14.3	17.1	10.3	32.0	19.7	238
1969	8.44	14.3	17.1	10.3	32.2	20.0	241
1970	8.49	14.3	17.1	10.3	32.5	20.3	243
1971	8.54	14.4	17.1	10.4	32.8	20.5	245
1972	8.58	14.5	17.0	10.4	33.1	20.7	248
1973	8.62	14.6	17.0	10.4	33.4	20.8	250
1974	8.68	14.7	16.9	10.5	33.7	21.0	252

APPENDIX C

KINTNER AND KLAIBER INDEX OF CONFORMITY [9]

The authors constructed the index by scoring individual East European countries on conformity to Soviet policy in seven broad areas. Conformity is defined as "the adoption, pursuit or articulation of policy positions by East European countries in accordance with related Soviet policies or objectives" [9]. The seven indicators are each weighted in proportion to the relative importance of the indicator. The seven indicators are listed below with the scoring range of assigned weights.

Indicators	Assigned Weight
1. Membership in the Soviet bloc	0-20
2. De Facto participation in COMECON	0-08
3. De Facto participation in WTO	0-08
4. Use of military force on EE state by USSR	0-15
5. Criticism by USSR of EE state	0-02
6. Criticism by EE state of USSR	0-02
7. EE conformity to Soviet policy regarding relations between Communist states, relations between Communist states and the West, major developments within USSR	0-3.5

The authors examined each EE country over the 1956-1968 time frame computing a total score for each year. The yearly

scores were aggregated and each country was ranked for conformity on the relative magnitude of its total. The result is displayed below with a high score meaning low conformity and low score high conformity.

BUL	2
CZ	5
GDR	1
HUN	3
POL	4
RUM	6

APPENDIX D

LINDEN INDEX OF DEVIANCE [10]

Linden constructed two separate indices, one for use in testing interactive deviance and the second to test attitudinal deviances. To construct the interactive index the author coded all bilateral national-level interactions (1550 total events) for each country and various interaction partners (USSR, EE, West, Peoples Republic of China, Yugoslavia, Albania, non-aligned nations, Arab States, U.S. and Federal Republic of Germany). Each event was ranked in importance from 1-5 (i.e., 1 - establish diplomatic relations to 5 - scientific or cultural exchanges, etc.). The scores awarded were aggregated and precentage interaction with each interaction partner was computed. The author then uses the percent interaction scores to calculate a WTO mean, from which Z scores are calculated as standard deviation difference of each country from the WTO mean. The Z scores are then rank ordered to produce the interactive index shown below.

Interaction Index of Deviation

BUL	2*		BUL	5**
CZ	4		CZ	3
GDR	6	⟹ Converting to a	GDR	1
HUN	5	conformity index	HUN	2
POL	3		POL	4
RUM	1		RUM	6

*1 means most deviation	**1 means most conformity
6 means least deviation	6 means least conformity

The attitudinal index was constructed using 46 events or occurrences which provided a stimulus thought to provoke an official reaction indicating the WTO member country's attitudinal or ideological position with respect to the USSR. Each country's reaction to the event was ranked by three independent coders who scored the reaction using the following criteria:

Strongly positive; strongly supportive; praise	+3
Positive; support	+2
Mildly positive; tend to support	+1
Neutral; ambiguous	0
Mildly negative; tend to criticize	-1
Negative; criticize; discourage	-2
Strongly negative; strongly oppose; condemn	-3

A WTO mean score was computed for each event. From these correlations with the WTO mean a result was provided which could be ordered to represent deviance from the typical WTO state. The attitudinal index follows.

Country	Rank
YUG	1
RUM	2
CZ	3
GDR	7
BUL	6
POL	5
HUN	4

$\Rightarrow$ Converting to conformity index

BUL	2
CZ	5
GDR	1
HUN	4
POL	3
RUM	6

APPENDIX E

MX CORRELATIONS (ACDA)

	BUL	CZ	GDR	HUN	POL	RUM
$BULMX_t$	---	.863	.862	.853	.921	.808
$CZMX_t$	.863	---	.944	.911	.936	.53
$GDRMX_t$	.862	.944	---	.947	.973	.622
$HUNMX_t$	.853	.911	.947	---	.929	.70
$POLMX_t$	.921	.936	.973	.929	---	.70
$RUMMX_t$	.808	.53	.622	.7	.7	---
$BULMX_{t-1}$	---	.917	.896	.896	.926	.731
$CZMX_{t-1}$	.808	---	.939	.895	.914	.492
$GDRMX_{t-1}$	.87	.939	---	.956	.976	.641
$HUNMX_{t-1}$	.85	.952	.907	---	.926	.616
$POLMX_{t-1}$	.94	.946	.972	.934	---	.712
$RUMMX_{t-1}$	.816	.584	.54	.679	.611	---
$FGRMX_t$	.838	.865	.828	.906	.811	.639
$FGRMX_{t-1}$	.754	.908	.811	.885	.789	.505
$YUGMX_t$	.866	.839	.889	.786	.864	.604
$YUGMX_{t-1}$	.793	.739	.942	.881	.902	.713
$USSRMX_{t-1}$	.899	.933	.977	.914	.989	.639
$USSRMX_t$	.875	.942	.982	.907	.987	.599
$NATOT_t$	.211	.573	.585	.4	.477	.185
$NAEXC_t$	.899	.969	.94	.94	.94	.642
$NAEUR_t$	.895	.973	.947	.945	.946	.639

	BUL	CZ	GDR	HUN	POL	RUM
$NATOT_{t-1}$	.362	.648	.742	.616	.647	.099
$NAEXC_{t-1}$	.852	.984	.939	.929	.923	.563
$NAEUR_{t-1}$	.855	.986	.934	.929	.928	.562
GNP_{t}	.945	.887	.955	.916	.981	.712
$TRATOT_{t}$	.956	.884	.892	.87	.897	.731
$TRAUSSR_{t}$	.934	.909	.945	.905	.985	.783
$TRAEE_{t}$	.981	.886	.899	.835	.934	.811
$TRAWEST_{t}$	.79	.847	.843	.852	.792	.703
$BPTOT_{t}$	---	-.481	-.407	-.034	.561	---
$BPUSSR_{t}$	.67	-.235	.38	.227	.535	.415
$BPEE_{t}$	-.616	-.314	-.077	.293	-.097	.238
$BPWEST_{t}$	-.575	-.541	-.688	-.408	-.602	.27
$TURMX_{t}$	.978	---	---	---	---	---
$TURMX_{t-1}$	.960	---	---	---	---	---
$GREMX_{t}$	.835	---	---	---	---	---
$GREMX_{t-1}$	.902	---	---	---	---	---

APPENDIX E

MX CORRELATIONS (SIPRI)

	BUL*	BUL**	CZ*	CZ**	GDR	HUN	POL	RUM
$BULMX_t$	---	---	.609	.574	.651	.66	.567	.438
$CZMX_t$	.609	.574	---	---	.871	.811	.836	.852
$GDRMX_t$	.651	.746	.871	.922	---	.892	.966	.94
$HUNMX_t$	.66	.680	.811	.831	.892	---	.805	.834
$POLMX_t$	.567	.666	.836	.930	.966	.865	---	.977
$RUMMX_t$	.438	.552	.852	---	.94	.834	.977	---
$BULMX_{t-1}$	---	---	.421	.534	.638	.668	.609	.474
$CZMX_{t-1}$	.755	.760	---	---	.937	.91	.879	.829
$GDRMX_{t-1}$	.639	.722	.752	.851	---	.845	.944	.896
$HUNMX_{t-1}$	.586	.667	.669	.788	.837	---	.883	.812
$POLMX_{t-1}$	.564	.678	.823	.928	.96	.833	---	.96
$RUMMX_{t-1}$	.498	.642	.838	---	.961	.837	.974	---
$FGRMX_t$	.854	.884	.59	.567	.754	.675	.737	.628
$FGRMX_{t-1}$	.627	.685	.478	.589	.745	.645	.781	.687
$YUGMX_t$	.738	.826	.547	.571	.752	.604	.723	.611
$YUGMX_{t-1}$	.693	.783	.588	.631	.792	.693	.715	.65
$USSRMX_{t-1}$	.63	.732	.768	.864	.948	.763	.944	.905
$USSRMX_t$	.618	.748	.799	.887	.954	.766	.955	.924
$NATOT_t$	.116	.170	.713	.760	.644	.574	.704	.808
$NAEXC_t$	.75	.836	.726	.768	.883	.711	.882	.808
$NAEUR_t$	.74	.827	.729	.777	.892	.723	.893	.822

*Raw data/**Smooth data

	BUL*	BUL**	CZ*	CZ**	GDR	HUN	POL	RUM
$NATOT_{t-1}$	.289	.344	.793	.885	.825	.839	.855	.903
$NAEXC_{t-1}$	.656	.743	.659	.758	.892	.737	.905	.844
$NAEUR_{t-1}$	.648	.739	.663	.767	.895	.736	.912	.853
GNP_t	.653	.774	.703	.785	.913	.72	.887	.809
$TRATOT_t$	.649	.720	.531	.605	.819	.569	.719	.659
$TRAUSSR_t$	.653	.768	.586	.629	.892	.646	.886	.562
$TRAEE_t$	.709	.810	.568	.635	.832	.52	.763	.657
$TRAWEST_t$	.428	.539	.491	.580	.76	.55	.575	.647
$BPTOT_t$	---	---	.008	---	-.333	.022	-.291	---
$BPUSSR_t$	.384	.394	-.319	-.404	-.342	.076	.343	.394
$BPEE_t$	-.406	.446	.008	.006	-.087	.077	.009	.285
$BPWEST_t$	-.174	-.224	-.007	-.107	-.567	-.097	-.352	-.655
$TURMX_t$	---	.818	---	---	---	---	---	---
$TURMX_{t-1}$	---	.801	---	---	---	---	---	---
$GREMX_t$	.573	.691	---	---	---	---	---	---
$GREMX_{t-1}$	.648	.763	---	---	---	---	---	---

APPENDIX F

RUMANIAN ECONOMIC AND POLITICAL DEVELOPMENT SINCE WORLD WAR II

Pre-Communist Rumania was an underdeveloped agrarian country rich in natural resources. Just prior to World War II, 80% of the employed population was engaged in agriculture amounting to one-half of the Gross National Product [13]. The petroleum reserves of Rumania are the largest west of the USSR, but prior to 1940 the bulk of the oil was exported as crude with little refining into petroleum products. Thus, prior to World War II Rumanian trade consisted almost entirely of exported agricultural products and raw materials, while imports were exclusively finished goods.

The entry of Rumania into the communist sphere occurred with the Soviet occupation of October, 1944 [14]. The regime of Petra Groza was installed by the Soviets in 1945 and a systematic reorientation toward the USSR and away from the West was started [14]. A strict subservience to the USSR was maintained and the exploitation of the country's national resources continued in the name of war reparations. The reconstruction of war-torn Rumania was secondary; in fact, Moscow directed the Rumanians to reject Marshall Plan aid from the West [15].

At the time of Stalin's death in 1953, the Rumanian Communist Party had set forth on a plan to industrialize the country. The five year Plans, beginning in 1949, called for

increased capital investment in heavy industry, and while major progress was made, the population suffered from lack of consumer goods. Trade existed almost entirely within the Eastern bloc, with approximately seventy percent with the USSR at prices and conditions detrimental to Rumania [14]. Even though the Stalinists of the Rumanian Communist Party blindly followed the Kremlin directives, an underlying struggle was taking place in the party between Rumanian nationalists and Moscovites.

In 1952-1955 the Rumanian Workers Party under Gheorghe Gheorghiu-Dej began to espouse the so-called "New Course" which called for attainment of economic goals by international cooperation with all nations [14]. This ran contrary to the Soviet COMECON plan which called for specialization among members. This plan would relegate the production of raw materials and agricultural products to Bulgaria and Rumania, while more developed members specialized in manufacturing. But by 1955, trade with non-communist countries had reached $60,000,000.00, approximately 20% of total trade. Clearly, the Rumanian leadership did not plan to remain a poor-cousin to the GDR, Czechoslovakia, Poland and the USSR.

In 1956 the Hungarian uprising and the near revolt in Poland induced the Soviets to moderate its dominant stance with the satellite nations. More favorable trade terms, extension of credits and increased quantities of raw materials and industrial equipment were used to keep the tide of revolt from spreading. It was during the period of appeasement that the Soviets were

approached about removal of their troops from Rumania. The actual withdrawal of troops eventually occurred in July, 1958. Floyd [15], attributes this remarkable achievement to Kremlin confidence in the stability of the Gheorghiu-Dej regime and its loyalty to Moscow. The terms under which Soviet troops departed are not known, but clearly the dissident ambitions of Rumanian leaders had not yet surfaced.

By 1958 Rumanian industrial output had increased 450% in ten years [15]. The country was growing economically and looking for increased technology and industrial equipment from the West. The Soviet occupation was ended and Rumanian leaders were firmly in control. In spite of this, Rumanian leadership maintained a strong Stalinist stance utilizing the secret police to purge dissident behavior. Soviet foreign policy was consistently praised as evidenced by the support given to the 1956 intervention in Hungary.

The first signs of conflict with the Soviets began as Rumanian leaders began to lay the economic plans for increased industrialization in the 1960's. Floyd [15] maintains that the Soviets began to resist a plan that would lead toward development of an independent industrialized Rumania. The Soviets wanted the interdependence of the pact countries to bind the alliance together.

Virtually all of the studies concerning the Rumanian-USSR split stress the economic independence asserted by the Rumanians in the mid- to late-1950's as the seed of the dispute. The

humiliation of Khruschev brought about by the Cuban missile crisis, and the Sino-Soviet dispute of 1962 precipitated a weakness in the Soviet leadership that the Rumanians exploited. Floyd [15] points to the active opposition (led by Rumania) during 1962-1963 to a Khruschev plan to use COMECON to coordinate and direct the national economies of the members as a single entity. It was during 1964 that the first outright defiance of Moscow occurred when the RWP published "a Statement on the Stand of the Rumanian Workers Party Concerning the Problems of the World Communist and Working-Class Movement". This document publicly challenged the Soviet's proposal for establishment of a Russian dominated economic empire with statements like

> "The idea of a single planning body for all COMECON countries has the most serious implications........To hand over these levers to the competence of some super-state or extra-state bodies would be to turn sovereignty into a concept without any real content." [10]

The Khruschev plan for integrating the economies of the WTO countries was finally rejected at a summit meeting of COMECON leaders in Moscow in July 1963. Floyd [15] calls it

> "...a notable achievement on the part of the Rumanians, for it was the first time, as far as we know, that the Russians had been forced to abandon a major line of policy in the communist camp by what could be called peaceful democratic means." [15]

By 1963-1964 the Sino-Soviet dispute was at its height. The Chinese challenge to Moscow focused on ideological differences as well as territorial problems [14]. Up until 1962, Rumania still publicly supported the Soviets and even withdrew its

Ambassador from Albania when that country switched to the Chinese camp [15]. In 1963 a general warming to the Chinese occurred and relations were re-established with Albania. As the Sino-Soviet dispute grew in intensity, Rumania was carefully avoiding the anti-Chinese gestures occurring elsewhere in Eastern Europe. In October 1964, Khruschev was replaced, no doubt caused by the erosion of power brought about by his failures in the Berlin crisis, Cuban confrontation, the COMECON plan, the "quiet" Rumanian revolt, and the great Communist schism with the Chinese.

The Rumanian Plan for rapid industrialization continued with increased trade with the West and a reduction of economic dependence on CMEA countries. This induced Rumania to assert more political independence which resulted in a growth of Rumanian nationalism. By no means was Rumania rejecting Communism for Capitalism, as harsh repressive actions were still common in dealings with political enemies and dissidents, but the leadership developed a "Rumanian First" philosophy that was incompatible with the Soviet domination in previous years.

In March 1965 Gheorghiu-Dej died and was succeeded by Nicolae Ceausescu [14]. Gheorgiu-Dej was a shrewd politician of considerable ability who walked a diplomatic tight-rope in his skillful maneuvering with the Soviet Union. Ceausescu and the top Rumanian leaders were with Gheorgiu-Dej from the beginning in 1949 when the decision to transform Rumania into an industrially independent nation was made. Ceausescu has

continued in the manner of Gheorghiu-Dej with outspoken expressions of national sovereignty. Linden [10] categorizes these expressions as 1) the existence of national differences in building socialism and the right of each party to develop its own policy; 2) the call for the abolition of military blocs who are blamed for continuing international discord and the lack of world peace, and 3) the responsibility of small and medium-size states for producing and protecting world peace. This statement rejects supranational decision making in favor of the inviolable rights of national sovereignty. The subsequent invasion of Czechoslovakia in 1968 brought a sharp denunciation by Ceausescu.

> "The thesis that some are attempting to accredit, of late, and according to which the joint defense of the socialist countries against an imperialist attack, would pre-suppose limitation or renunciation of the sovereignty of any Treaty Member-State, does not accord with the principles of relationships between the socialist countries and can by no means be accepted. Not only does membership in the Warsaw Treaty not render questionable the sovereignty of the member-countries, not only does it not limit in any way their state independence, but on the contrary, as provided for the Treaty itself, it serves for strengthening the independence and national sovereignty of each state." [10]

The strong stand for national sovereignty and economic independence resulted in strong popular support for the international stance of the Gheorgiu-Dej and Ceausescu regimes. This and the strong anti-Russian feeling helped propel the Rumanian leadership on its independent course.

In summary, the overriding stimulus that induced the Rumanian deviance was economic. There is general agreement that Rumania did not want to remain in the Soviet-cast mold as provider of agricultural products and raw materials to the industrial CMEA countries. The strong nationalistic feeling generated by the Rumanian leadership led to rejection of the Soviet plan for supranational planning and control through COMECON and propelled Rumania on a rapid course of industrial growth. No doubt the absence of Soviet troops in Rumania enabled the assertion of independence but it was delicate political maneuvering, shrewd economic logic and quiet diplomacy that prevented a military response from the Soviets.

APPENDIX G

HILDRETH-LU GRID SEARCH PROCEDURE [23]

The linear model, Equation G-1, requires certain basic assumptions be true about the data.

1. The relationship between Y_i and X_i is approximately linear.

2. The X_i are nonstochastic variables whose values are fixed.

3. The error terms e_t are $N(0,\sigma^2)$ and uncorrelated (i.e., $E(e_i,e_j) = 0$ for $i \neq j$).

$$Y_i = B_1 + B_2 X_i + e_t \qquad \text{Equation G-1}$$

Under these assumptions the method of least-squares produces the best linear unbiased maximum likelihood estimators. When serial correlation is present, assumption three is violated, and we are not guaranteed that our estimators will be unbiased MLE's. To correct for serial correlation we need to compute the correlation between error terms and remove it from the data. Equation G-2 shows the correlation relationship between error terms. Equation G-3 shows the generalized differencing procedure where the linear model is altered by multiplying by $(1-\rho)$ so that error terms become independent (i.e., ρ is multiplied by the previous time period value and the product subtracted).

$e_t = \rho e_{t-1} + V_t$

where V_t is $N(0,\sigma_v^2)$

and $E[V_i,V_j] = 0$ for $i \neq j$

and $0 \leq \rho \leq 1$ <u>Equation G-2</u>

$$Y_t - \rho Y_{t-1} = B_1 (1-\rho) + B_2 (X_t - \rho X_{t-1}) + V_t$$

<u>Equation G-3</u>

By construction, now the error term meets the requirements of assumption three.

To test for the presence of serial correlation the Durbin Watson Statistic listed below is computed.

$$DW = \frac{\sum_{t=2}^{T} (e_t - e_{t-1})^2}{\sum_{t=1}^{T} e_t^{\,2}}$$

We can now test the hypothesis as follows:

H_o: No serial correlation present.

H_1: Negative serial correlation present..

Or

Positive serial correlation present.

a. $2 < DW < 4-d_u$ or $d_u < DW < 2$ ACCEPT H_o

b. $4-d_l < DW < 4$ or $0 < DW < d_l$ REJECT H_o

c. Other Indeterminate

d_l and d_u are lower and upper limit values based on the number of independent variables and the significance level.

The Hildreth-Lu procedure is an iterative grid search method where values of ρ are specified within a range thought to contain the true ρ. For each value of ρ the generalized differencing described above is performed on the data until the minimum error sum of squares (ESS) is observed. The ρ producing the minimum ESS is optimal and is used in Equation G-3 to adjust the data so that least squares regression can be performed giving Equation G-4.

$$Y_t^* = B_1 (1 - \rho) + B_2 X_t^*$$
$$\text{where } Y_t^* = Y_t - \rho Y_{t-1}$$
$$X_t^* = X_t - \rho X_{t-1}$$

Equation G-4

```
    ∇A3RSR [⎕]∇
  ∇ Z←A3RSR X
[1]   X←A3R X
[2]   Z←A3R SPLIT X
[3]   →2×(ρρρX←Z)×0≠+/|Z−X
  ∇
    ∇A3R [⎕]∇
  ∇ Z←A3R X;Y1;Y2;X1;X2;N;C
[1]   Z←ONE3 X
[2]   →1×(ρρρX←Z)×0≠+/|Z−X
  ∇
    ∇ONE3 [⎕]∇
  ∇ Z←ONE3 X;Y1;Y2;X1;X2;N;C
[1]   Y1←(3×X[2])−2×X[3]
[2]   Y2←(3×X[N−1])−2×X[¯2+N←ρX]
[3]   X1←Y1,¯1↓X
[4]   X2←1↓X,Y2
[5]   Z←(Y1,X,Y2)[(⍳N)+1+(C=X1<X)−(X≤X2)=C←X1<X2]
  ∇
    ∇SPLIT [⎕]∇
  ∇ Z←SPLIT X;P;Q;R;S;T;N;I;J;C
[1]   P←¯3↓X
[2]   Q←¯2↓1↓X
[3]   R←¯1↓2↓X
[4]   S←3↓X
[5]   I←(((P<Q)×R>S)+(P>Q)×R<S)×Q=R
[6]   Q←(X←X[1],X,X[N])[1+I←(I≠0)/I←I×⍳¯3+N←ρX]
[7]   R←(3×Q)−2×X[I]
[8]   P←X[I+2]
[9]   T←(3×S←X[I+4])−2×X[I+5]
[10]  X[I+2]←(R×1=J)+(P×¯1=J)+Q×0=J←(C=P<Q)−(Q≤R)=C←P<R
[11]  X[I+3]←(T×1=J)+(P×¯1=J)+S×0=J←(C=P<S)−(S≤T)=C←P<T
[12]  Z←1↓¯1↓X
  ∇
```

```
∇ R←CORRELATION W;Z;C;S;CW
  C←(⍉Z)+.×Z←W-(⍴W)⍴(MEANS←+⌿W)÷1↑⍴(¯2↑1,1,⍴W)⍴W+⍴CW←''
  R←'BF8.3' FMT(0,⍳⍴S),[1](⍳⍴S),C÷S∘.×S←(VARS←+⌿Z*2)*0.5
∇

 ∇FMT [⎕]∇
∇ OL←E FMT R;S;W;⍙;G;X;T;K;J;M;Q;P;D;N;O;L;B;V;CH;H
  N←Q←1↓M←⍴R←(1⌈¯2↑⍴R)⍴R
  OL←((1=1↑M)↓ 1 0 ×M←M+2↑H←1<⍴CH←CW,',')⍴⍙←'0123456789.'
 →E×⍳(N←0=N)∨V←1≥⍴S←,E
LO:→~⍳V∨(×P←4×Q=⍴K←⍴X←' ')∧~/('A',O←'⎕')∊S
  →(LO+(V←0=⍴S←J↓S)+⍳B=M[2]←1),L-(⍳×B←O+.=K),P×~'A'∊K←K,(J←S⍳',')↑S
 →E+×⍴S←'TEXT DELIMITER'
  →L3-3××(⍴G←K=K←(K∊¯1↓⍙)/K)⌊W←⍴X←(⍴K←(K⍳O)↑K)↓(-(⌽K)⍳O)↓K
L:→(D←~1↑G←K∊⍙)/L3-2×(⍴K)≠W←1↑O←'XA'∊K←(~K∊' ,')/K
  →L3×⍳(B≠+/G)∧×M[2]←10⊥|1-⍙⍳(B←|1-G⍳O)↑K
  →L3-⌽O,-(L←'EFI'∊K)/×W←10⊥|1-⍙⍳(|1-G←B⍳'.')↑B←(1-(⌽G)⍳O)↑K
 ⍙←(1↓⍴X←((1⌈⍴⍙)⌊(M[1]-H),W)↑⍙)⌽⍙
L3:→(HD×⍳H∧~'X'∊K),E-⍴X←-W,D←O⍴P←((M-H,0)×1,W)⍴X
  →L4-⍳~1↑L,Q←1↓⍴R←(0 1 ×⍴P←R[;⍳M[2]←Q⌊M[2]⌈Q×V∧D])↓R
  P←P÷10*L←⌊10⍟|P+0=P
  →L3×⍳0=J←+/B←('B'∊K)∧0=P←(⌊0.5+N×,P)÷N←10*D←10⊥|1-⍙⍳G↓B
L4:→(⍴1↓⍴L)/F-⍴⍴X←(1 0 ×⍴G←J⍴T\'¯')⍴J←J,O←∨/T←0>P←B/P
  →(×L←(0⌈L×J←'Z'∊K)⌈.×~T←(T+O←1+⌊10⍟1⌈|P)>O+L←W-D+O+~2↓L)/L/F,F,I
 →E+×⍴S←'FIELD WIDTH'
  →L4+1+⍳((J[2]←L∨.<0)+O←1+10⌈.≤|L←(B/,L)+T←10=|P)>W-D+O+3
 T←~J←P[T/⍳1↑J]←L←⍴1⍴X←'E','+0¯'[J⍴2-×L],⍙[1+⍉(O⍴10)⊤|L]
F:→(J∨2≥D×~'T'∊K)/I,N←⍴X←⍙[11,1+⍉(D⍴10)⊤⌈N×1||P],X
  D←,(-N)↑(D⌈.×⍉X[;2+D]≠1↑⍙)∘.<D←⍳D-1
  X←N⍴X,X[D/⍳⍴X←,X]←'-'
I:→(J←J∨0=+/O←0⌈L-O)/I+⍴D←⍴P←G,⍙[1+⍉(L⍴10)⊤⌊|P]
  P←D⍴(,O←G⌽O)\(,O←O∘.<(-G)⌽⍳L+G←1↓⍴G)/,P
  →HD-⍳J∨L←~'L'∊K,P[T/⍳D←1↑X←⍴P←P,X;]←'*'
  P←X⍴(,⌽O)\(,O←~X↑~O)/,P
  →(~H)/E-N←1,D←O⍴P←B⍀(D,X←W×1-2×L)↑P
HD:CH←(⍴K←(¯1↑D←0,(M[2]⌊⍴D)⍴D←(','=CH)/⍳⍴CH)⍴CH)⌽CH
  D←,(M[2],X)↑ 0 ¯1 ↓(M[2],B)⍴(,⌽D∘.≥⍳B←⌈/D←1↓D-¯1⌽D)\K
  →(LO-V∧×Q),⍴OL←OL,((1=1↑M)↓M×1,W)⍴D,,P
E:K←'NO VALID E, I, OR F PHRASE'
  'FMT PROBLEM      ',K;(1,⍴S)⍴S
∇
```

```
    ∇SCAT [⎕]∇
  ∇ W←SCAT Z;N;X;Y;C;R;U;S;L;I;J;K;UT;CL;G;D;B;A;O;V
[1]   →3×⍳(×/N)>+/N←⍴Z
[2]   Z←⍉(2,⍴Z)⍴(⍳⍴Z),Z←,Z
[3]   Y←Z[;1+⍳C←¯1+(⍴Z)[2]]
[4]   R←⍴Z←X←,Z[;1]
[5]   L←U←S←2⍴0
[6]   J←1+0×⍴(D←NDIVX,NDIVY),B←WID,DEP
[7]   UT←10*⌊10⍟CL←1E¯20+((U[J]←⌈/Z)-S[J]←⌊/Z)÷D[J]
[8]   S[J]←UT×⌊S[J]÷UT←UT[1↑⍋|CL-UT←(1 2 5)×UT]
[9]   U[J]←UT×⌈U[J]÷UT
[10]  L[J]←1+G×⌊(B[J]-1)÷G←(U[J]-S[J])÷UT
[11]  Z←,Y
[12]  →7×⍳3>J←J+1
[13]  A←(⌽L)⍴0
[14]  X←1+⌊0.5+(L[1]-1)×(X-S[1])÷U[1]-S[1]
[15]  Y←1+⌊0.5+(L[2]-1)×(Y-S[2])÷U[2]-S[2]
[16]  I←1
[17]  →20×⍳1<C
[18]  A[Y[I;1];X[I]]←10⌊A[Y[I;1];X[I]]+1
[19]  →18+6×R<I←I+1
[20]  J←1
[21]  D←0=V←A[Y[I;J];X[I]]
[22]  A[Y[I;J];X[I]]←(10×V>K+1)+((K+1)×K=V)+(K←35-2×J)×D
[23]  →21×⍳R≥I←I+1
[24]  →21×⍳C≥J←J+I←1
[25]  O←(⌽⍴A)⌊1⌈1+⌊0.5+(L-1)×S÷S-U
[26]  A[;O[1]]←A[;O[1]]+36×0=A[;O[1]]
[27]  A[O[2];]←A[O[2];]+35×0=A[O[2];]
[28]  W←' ∘23456789BLLKKJJIIHHGGFEEEDDCCBBAA-|'[1+⊖A]
[29]  'RANGE OF X: ';S[1],U[1]
[30]  'RANGE OF Y: ';S[2],U[2]
  ∇
```

```
      ∇REGRESS [⎕]∇
    ∇ Z←Y REGRESS X;N;K;C;XPXINV;XPY;BETA;RSS;TSS;S2;ESS
[1]    X←(2↑(⍴X),1)⍴X
[2]    X←(0,1-∆INTERCEPT)↓1,X
[3]    XPXINV←⌹(⍉X)+.×X
[4]    BETA←XPXINV+.×XPY←(⍉X)+.×Y
[5]    RSS←((⍉BETA)+.×XPY)-C←((+/Y)*2)÷N←⍴,Y
[6]    'REGRESSION SS: ';,RSS;'    N=';N
[7]    'ERROR SS: ';,ESS←TSS-RSS;'    TOTAL SS: ';,TSS←((⍉Y)+.×Y)-C
[8]    'RESIDUAL VARIANCE: ';S2←,ESS÷N-K←⍴,BETA
[9]    'R SQUARE: ';,RSS÷TSS
[10]   C⌹←'BETA,T-STATISTICS'
[11]   'F15.4' FMT⍉(2,⍴,BETA)⍴(,BETA),(,BETA)÷(1 1 ⍉V←S2×XPXINV)*0.5
[12]   'DO YOU WANT A PRINTOUT OF THE VAR-COV MATRIX?'
[13]   →A1×⍳'Y'≠1↑⍞
[14]   'VARIANCE-COVARIANCE MATRIX: ',⌊⌹←''
[15]   'E12.4' FMT V
[16]  A1:'F RATIO: ';,(RSS÷K-1)÷S2;'    DF ARE: ';K-1;' AND ';N-K
[17]   'DURBIN-WATSON: ';(+/((1↓,C)-(¯1↓,C))*2)÷+/(,C←Y-X+.×BETA)*2
[18]   Z←⍉(2,N)⍴(,X+.×BETA),,C
[19]  B1:'DO YOU WANT TO FORECAST A VALUE OF Y?'
[20]   →0×⍳'Y'≠1↑⍞
[21]   'ENTER X VECTOR'
[22]   'FORECASTED Y VALUE: ';(XT←(1-∆INTERCEPT)↓1,⎕)+.×BETA
[23]   'VARIANCE OF FORECAST ERROR: ';S2×1+XT+.×XPXINV+.×⍉XT
[24]   →B1
    ∇
      ∇RHOSEARCH [⎕]∇
    ∇ D←RHOSEARCH W;N;T;Z;RHO;ESS;BETA;Y;X
[1]    N←1↑⍴W
[2]   B1:'ENTER LOWER BOUND, UPPER BOUND, AND INCREMENT FOR RHO.'
[3]    T←⍳0×R←1↑RHO←⎕
[4]   A1:Z←(1 0 ↓W)-R× ¯1 0 ↓W
[5]    T←T,R,ESS←+/(,Y-X+.×BETA←(Y←((N-1),1)↑Z)⌹X←1, 0 1 ↓Z)*2
[6]    →A1×⍳RHO[2]≥R←R+RHO[3]+0×⍴C⌹←'RHO,ESS'
[7]    'TF7.3,TF15.4' FMT(((⍴T)÷2),2)⍴T
[8]    'DO YOU WANT TO REFINE THE GRID FOR RHO?'
[9]    →B1×⍳'Y'=1↑⍞
[10]   'ENTER ''OPTIMAL'' VALUE FOR RHO.'
[11]   D←(1 0 ↓W)-(R←⎕)× ¯1 0 ↓W
    ∇
```

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